Coastal Energy Transportation Study: Alternative Technologies for Transporting and Handling Export Coal

By

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Coastal Energy Transportation Study
Phase III, Volume 1

Alternative Technologies for Transporting and Handling Export Coal

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PREFACE

This report is the first of three reports from the third phase of a three-phase study funded by the Coastal Energy Impact Program and conducted by the UNC Institute for Transportation Research and Education. Phase I of this study, conducted in 1980, identified and documented the transportation needs necessary to support a group of energy projects proposed for the coastal area of North Carolina. Phase II of this study, conducted from September 1980 to August 1981, had two distinct parts:

1. An assessment of impacts of the Outer Continental Shelf (OCS) oil and gas exploration and production activity with emphasis on the transportation requirements and alternative locations for on-shore support base(s) in North Carolina, and

2. An assessment of impacts of coal exports from North Carolina with emphasis on the transportation requirements of alternative locations and capacities of coal terminals.

Phase III of the Coastal Energy Transportation Study, conducted from September 1981 to August 1982, is an assessment of impacts of transport and storage of all other energy feedstocks and products, including crude oil, refinery products, peat, wood, and biomass material, as well as a more detailed analysis of coal transportation to North Carolina's ports. The three reports prepared under Phase III are entitled:

1. "Coastal Energy Transportation Study: Phase III Volume 1, Alternative Technologies for Transporting and Handling Coal;"

2. "Coastal Energy Transportation Study: Phase III Volume 2, Impact Assessment of Coal, OCS, and Other Energy Projects on North Carolina's Coastal Zone;" and

3. "Coastal Energy Transportation Study: Phase III Volume 3, Coal Shipments by Rail: Regional Impacts and Opportunities."

Separate reports were prepared documenting the results of Phase I and Phase II. These previously published reports are entitled:

1. "Coastal Energy Transportation Study: Phase I, An Analysis of Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone" (December 1980, CEIP Report No. 1);

2. "Coastal Energy Transportation Study: Phase II Volume 1, A Study of OCS Onshore Support Bases and Coal Export Terminals" (August 1981, CEIP Report No. 2);

3. "Coastal Energy Transportation Study: Phase II Volume 2, An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone" (January 1982, CEIP Report No. 3); and

4. "Coastal Energy Transportation Study: Phase II Volume 3, An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone" (August 1981, CEIP Report No. 4).

All of these reports are available from the Office of Coastal Management, North Carolina Department of Natural Resources and Community Development.

The scheduling of the various tasks for each phase of the study was designed to permit the study team to complete key activities in advance of certain critical dates. For example, many of the tasks related to OCS activity in Phase II were completed so that state, regional, and local decision-makers involved in the OCS program would have output prior to August 1981, the scheduled date for OCS Lease Sale #56 by the Bureau of Land Management.

The movement of export coal shipments through North Carolina is now underway. The contract with Alla-Ohio Coal Company to ship three million tons annually through the State Ports Authority (SPA) facilities in Morehead City was announced in October 1980; and the first shipment of export steam coal left Morehead City for Holland on May 13, 1981. Although the situation regarding the development of energy projects is constantly changing, this report is based on the most up-to-date information available at the time of printing.

The purpose of the Coastal Energy Transportation Study is to provide state and local governmental officials and policy-makers with sufficient background data and scenario analysis to permit informed, rational decision-making for energy- and transportation-related development activities affecting the state in general and the coastal zone specifically. The seven reports of this study (Phase I; Phase II Volumes 1, 2, and 3; and Phase III Volumes 1, 2, and 3) are not to be construed as either engineering analyses or as economic/feasibility studies sufficient by themselves to justify (or reject) specific alternatives of any development activity. Instead, the reports should be used as tools to effect better management of the state's resources and activities.

CONTENTS

FIGURES

TABLES

ACKNOWLEDGEMENTS

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ABSTRACT

Recent studies of the world coal dilemma have projected substantial increases in steam coal trade during the next two decades. Much of it will move by ships and will be destined for Western Europe and Pacific Rim countries where agressive policies to reduce OPEC oil dependence have already been formulated. Because most of the coal needed to satisfy this growing demand will have to be imported, it is likely that world trade in steam coal would expand several fold by the year 2000. How these increases in demand affect the coal export potential of the United States, what transporting and handling technologies are currently available or on the horizon, and which scenario for coal export terminals in North Carolina's Coastal Study Area will best serve the state's needs are explored in this study.

Existing technologies such as unit trains, barges, trucks, mechanical conveyors, and pneumatic and slurry pipelines are treated as inland transportation networks and systems, while coal transfer is considered to be part of the export terminal operation in the port area. In addition to these conventional technologies, a number of new systems have been proposed for moving and handling coal. Most promising of the proposals are the following new concepts or modifications of existing technologies: mine-to-ship systems, midstream transfer, barge-carrying vessels, shallow-draft vessels, and offshore deepwater concepts.

SUMMARY AND CONCLUSIONS

Based on the study of potential coal export terminal sites conducted in Phase II of this Coastal Energy Transportation Study, this report on "alternative technologies" was prepared. The approach to this study was to briefly review the current situation (Fall, 1981) concerning coal export potential from the United States and North Carolina, then to look at existing and developing technologies for transporting and handling coal. Alternative technologies that were explored include:

Existing Technologies:

- Conventional rail
- Coal unit trains
- Barges
- Trucks
- Pneumatic conveyor systems
- Mechanical conveyor systems
- Slurry pipelines
- Coal handling facilities at ports

Developing and Proposed Technologies:

- Mine-to-ship systems (combination of networks)
- Midstream transfer
- Barge-carrying vessels
- Shallow-draft vessels
- Offshore deepwater concepts

The most promising of these alternative technologies were then explored in the context of three development scenarios for North Carolina's Coastal Study Area.

Morehead City Region

Because of the unique advantages and limitations of the Port of Morehead City, one scenario appears to be most promising:

- Rail - barge system to bypass New Bern and Morehead City

Cape Fear River Region

Coal terminal location along the Cape Fear River from Wilmington to Southport faces a different set of problems than those encountered in Morehead City. Because of its geography and well-established rail infrastructure, new coal transport and loading technologies may not be needed in this region during the early years of development. The major problem could very well be lack of adequate ship channel depths to accommodate the larger, more efficient bulk vessels that are expected during the coming decade. Rather than dredge the 38-foot channel to a greater depth, the following scenario offers considerable promise:

- Employ wide-beam, shallow-draft vessels that could increase deadweight capacity up to 60 percent over conventional ships without any channel dredging

Offshore - Pender, Onslow, and/or Carteret County

The possibility of constructing an offshore coal export terminal complex in one of the two following locations offers a solution to many of the problems encountered by terminals in established port areas:

- Offshore coal terminal with onshore facilities in Pender County between Scotts Hill and Hampstead, North Carolina
- Offshore coal terminal with onshore facilities west of Morehead City in Carteret County

Recommendations

It is recommended that two definitive studies be undertaken to explore the feasibility of the four scenarios listed above. A Landside Feasibility Study would investigate the rail - barge scenario for the Morehead City region and the wide-beam, shallow-draft vessel scenario for the Cape Fear region. The feasibility of the two offshore terminal locations would be investigated in the second study. A detailed analysis of costs, technical feasibility, and environmental and social costs of a reasonable set of alternatives under each of these scenarios would provide decisionmakers with additional input towards the solution of a most complex problem.

1.0 THE OUTLOOK FOR ALTERNATIVE TECHNOLOGIES

Recent studies of the world coal dilemma have projected substantial increases in coal trade during the next two decades. Much of it will move by ship and will be destined for Western Europe and Japan where aggressive policies to reduce OPEC oil dependence have already been formulated. Because most of the coal needed to satisfy this growing demand will have to be imported, it is likely that world trade in steam coal could expand several-fold by the year 2000. How these increases in demand affect the coal export potential of the United States, what transport and handling technologies are currently available, what proposed technologies are on the horizon, and which scenario for coal export terminals in North Carolina's Coastal Study Area will best serve the State's needs will be explored in subsequent sections of this study.

1.1 Coal Export Potential

While anticipated steam coal trade is expected to increase dramatically, the United States' share of the trade will obviously depend on how well the nation prepares for the export market in comparison with other major suppliers. To place the problem in perspective, as recently as 1978 U.S. overseas steam coal exports totaled only 300,000 tons annually. By 1980 steam coal exports had jumped to 16 million tons a year and total U.S. coal exports, including metallurgical coal, reached a historical peak of 90 million tons.

Most of the coal produced in the world is consumed within the country in which it is mined and only about ten percent of world coal is traded internationally. Traditionally, a predominant share of these movements has been premium metallurgical coal which could sustain the high transportation cost. Most of the steam coal trade was between nearby countries such as the United States and Canada or Poland and West Germany.

A review of recent coal production and export projections, summarized in Table 1, suggests that steam coal exports will grow much more rapidly than metallurgical coal exports during the next 20 years. Primarily because of rapid conversion from oil to coal to generate electricity, demand for export steam coal is placing significant pressures on the transportation infrastructure, particularly at port terminals in the United States where transfer facilities have been unable to keep abreast of the demand. If the United States is to remain competitive in the world market as a supply source, these infrastructure weaknesses will have to be resolved or our primary competitors -- Australia, South Africa, and Poland -- will reduce our share of the market.

Several factors will determine our share of the export market. As in most markets, price will be a major constraint. But price is likely to be modified in some of the supply countries by an inability to produce as much export coal as is needed. Coupled with an unwillingness on the part of the consumers to depend on a single source of supply, many coal importing countries are looking for coal contracts where production and reserves are not a problem. With regard to production and reserves, the United States is truly in a unique position when compared with its principal export competitors. The U.S. is second only to the Soviet Union in both coal reserves and production and is likely to surpass the U.S.S.R. in production within the near future. Clearly, much of the export coal trade will originate in this country, and if the domestic coal industry can maintain the growth rate achieved from 1973 to 1980, U.S. coal production will grow from its current 835 million tons to 2.2 billion tons by the year 2000. This production rate could accommodate a domestic demand of 1.8 billion tons and still provide about 350 million tons of export capacity. Thus, it is apparent that the vast coal reserves and resources of the privately-controlled U.S. coal industry can be expanded to satisfy the predicted 248 million tons (Table 1) of export demand by the turn of the century.

TABLE 1. COAL PRODUCTION AND EXPORT PROJECTIONS

Year	Production (million tons annually)	Exports (million tons annually)		
		Metallurgical	Steam	Total
1980	830			90
1985	971-1118 (5)	55.2 (avg. of 9)	39.1 (avg. of 12)	94.3
1990	1223-1620 (4)	62.4 (avg. of 9)	68.8 (avg. of 12)	131.3
2000	1905-3077 (4)	74.4 (avg. of 4)	173.2 (avg. of 7)	247.6

Sources: WOCOL, ICE, NCA, and "International Bulk Journal"
Note: Number of forecasts are in parentheses.

1.2 Need for New Technologies

Any effort to estimate the potential U.S. share of the world steam coal market for the next two decades is encumbered by a number of uncertainties. Concerns such as price, security of supply, and competition from other coal exporting countries will have an impact on the market. Perhaps most significantly, if the United States does not develop a rational, comprehensive policy relative to coal exports, a large share of the market could be lost to foreign competitors.

If the U.S. is to capture and retain a major share of the world market it must also address the problems of inadequate channel depths in most of its harbors and limitations on present transportation infrastructure. In the area of transporting and handling coal for export, there is a growing awareness of a need for new technologies. If expansion of existing transport and terminal facilities fails to satisfy the growing demand for coal exports, new systems will be needed. A number of these alternative technologies, including conventional systems and proposed options, have been identified. Among the options available or proposed for handling coal for export are the following:

- Conventional Rail
- Unit Trains
- Barges
- Trucks
- Conveyor Systems
- Slurry Pipelines
- Pneumatic Pipelines
- Combination Vessels (OBO)
- Bulk Carriers
- Shallow-Draft Vessels
- Midstream Transfer
- Barge-Carrying Ships
- Offshore Loading Concepts
- System Combinations

Most of the research related to the development of alternative systems is being conducted by the private sector and there is confusion about what role, if any, the federal government should play in the evaluation and/or promotion of new technologies. Federal action in the form of channel dredging for example, would have a profound influence on the need to construct an offshore loading terminal or on the need to build large, dry-bulk vessels that could take advantage of economies of scale. Commitments to new technologies may not be rapidly implemented until federal policies become more definite.

2.0 EXISTING TECHNOLOGIES

Traditionally, the coal export industry has relied on rail transportation and to a lesser extent on barge transportation for the movement of coal from mine to port. Trucks and slurry pipelines have accounted for a very minor part of the long-haul market. In subsequent sections of this chapter coal movement will be discussed in terms of domestic inland transportation networks and systems, while coal transfer will be treated as a part of the export terminal operation in the port area.

2.1 Inland Networks and Systems

For purposes of this study existing coal movements will be classified into long and short distance systems. Long distance systems will encompass rail and barge movements, while short distance systems will primarily involve trucks, conveyors, and pipelines.

2.1.1 Long Distance Systems

Railroads

Railroads transport over 80 percent of the coal produced in the United States, and there is little doubt that the anticipated boom in coal exports during the next two decades presents the railroad industry with a great opportunity to further expand its traffic share. Of the 41 Class 1 railroads[1] in this country, almost 90 percent of total coal traffic moves on ten railroads. Three of the top four coal haul railroads dominate the present export market on the U.S. Atlantic coast:

Railroad	Port
1. CSX System	
Baltimore and Ohio	Baltimore
Chessie	Newport News
2. Norfolk and Western	Norfolk
3. Conrail	Philadelphia

[1] Railroads with annual operating revenue of over $50 million.

Basic types of rail coal movement classified from a rate standpoint are "single car", "bulk rate", and "dedicated unit train." Bulk rate is applicable where less-than-train-load lots of coal originate from one point. The dedicated unit train moves between one point of origin and one destination with a single commodity.

Unit Trains

The most efficient method of rail transportation from medium and large mining operations to export terminals is the unit train. A typical unit train would consist of one hundred 100-ton cars hauling a total of 10,000 tons of coal and providing nonstop service from loading point to destination.

Unit trains are loaded at normal plant rate where booms and chutes direct the output into coal cars or by flood-loading. Storage for unit train flood-loading is in open piles on the ground or in silos or bins. Ground storage is the most common method of accumulating enough coal for high-speed unit train loading.

The most significant contribution to efficiency made by the unit train concept is in the unloading procedure. A commonly used procedure for unit train unloading features bottom discharge batches in combination with some form of vibrator. Some export terminals, such as Chessie Coal Pier No. 14 in Newport News, utilize a rotary coal dumper that allows the rail cars to be turned and dumped without uncoupling or breaking an air line. Coal then is dumped onto a belt conveyor and moves to a loading tower where it is placed aboard the vessel. Port facilities that can take full advantage of the unit train concept by unloading a 110-car unit train in four hours or less are limited in number.

Experience gained in operating unit trains in semi-automatic fashion to supply steam generating stations provides some understanding of how the concept might be adapted for export coal. The following excerpt from the 1980 Keystone Industry Manual describes a typical operation (Keystone, 1980: 249):

For illustrative purposes we will describe in full a typical semi-automatic coal handling operation by rail. First at both loading and unloading points -- Cimarron Coal Company mines in Western Kentucky and the 3.1 megawatt generating station called Plant Bowen of the Georgia Power Company, near Cartersville, Georgia -- the trains are MOVING. The loading facility is arranged so that coal from a continuously operating overhead conveyor continuously pours into the cars passing beneath it. Each car takes about 100 seconds to fill so the entire train is loaded in less than two hours. Weighing is accomplished by scales on the conveyor to the overtrack loading tipple.

Unloading procedures at Plant Bowen, 370 miles from the mine, are considered quite dramatic. A loop track bringing the train into the plant area has a 900-foot-long trestle. As the train passes over the trestle, at speeds up to six miles per hour, a pickup shoe on each car rubs against a wayside third rail. Contact between the shoe and rail signals an air operated car unloading mechanism and coal drops out through the bottom of the car into the undertrestle area. Conveyors under this area then feed the coal either directly to the plant's boilers or to storage areas. A 7,000 ton train drops its entire contents in less than 30 minutes -- individual cars have been clocked at from 15 to 20 seconds to clear 100 tons of coal.

Scheduling of these trains is as precise and as dependable as transportation can be; however, frequently trains bunch. The advantage seen here in the total system concept for handling these bunched trains is the ability to continue the railroad transportation. One train directly behind the next train can run through the loop to discharge its coal, without stopping and waiting. This ability of the system to handle bunched trains leads to higher utilization of locomotives, crews and coal cars providing economic benefits to both the railroad and the power company. Each train makes three 740 mile round trips a week, taking about 48 hours to complete the mine-to-power plant-to-mine cycle. The trains run straight through as a unit and with the same motive power, making brief stops only for changing crews and for servicing. Due to the rapid unloading, no congestion of waiting trains occurs at the unloading site, hence, no waiting yards are necessary. Nearly SEVEN MILLION tons of coal are handled annually for this plant and eight trains of 70 cars each -- plus spares -- handle it with ease through continual cooperative efforts of mine, railroad, and receiver.

<u>Barges</u>

In 1977, the domestic inland waterway system carried over 130 million tons of coal (National Coal Association, 1979:III-2). Coal shipments accounted for about 25 percent of all barge tonnage moved on the inland waterways. Most of it originated on tributaries of the Mississippi River System (Table 2). Much of the export coal transported by barge moved down the Mississippi River for transfer to bulk carriers at one of the terminals in the vicinity of New Orleans. Increasing amounts of barged coal reaching this port are being loaded directly aboard ships by means of midstream transfer, a process designed to avoid ship delays at the terminal. The other port that is receiving substantial amounts of export coal by barge is Mobile where tows move down the Warrior River and transfer coal at the McDuffie Terminals' bulk loading facility.

Although the railroads continue to dominate coal transportation, inland waterways handled about 17 percent of the total in 1977. Most coal barges in operation on the inland waterway system are open-hopper designs with capacities ranging from 1000 to 2000 tons. Size of barge tows usually varies from 10 to 40 barges, with lock dimensions and river geometrics controlling the size. Coal movement is normally a one way operation and tows often return empty on short-distance hauls.

2.1.2 Short Distance Systems

The transport and transfer operations for coal exportation are similar to those for other solid dry bulk commodities: movement from one point to another is accomplished using trucks, mechanical conveyors (belt or screw conveyors), elevators and/or pneumatic conveying systems. The choice of system and equipment is site specific, depending on material to be handled, distances involved, and other factors. This section will discuss four modes of transfer for use in coal export activities. Trucks and mechanical and pneumatic conveying systems have been widely used in many process industries requiring the movement of bulk solids. The fourth transfer system is slurry pipelines. While not used as extensively in the process industries due to the nature of the materials and processes involved, slurry pipelines are receiving extensive study in the search for more efficient and less environmentally damaging methods of transporting coal from both Western and Appalachian coal fields to the growing domestic and world export markets.

Table 2

MAJOR COAL HAULING RIVER SYSTEMS, 1977

River System	Volume (1,000 tons)	Coal Originated as % of Total River Coal Shipments
Ohio	55,356	42.4
Monongahela	23,862	18.3
Green & Barren	13,220	10.1
Mississippi	9,753	7.5
Kanawha	4,958	3.8
Illinois	4,350	3.3
Tennessee	4,079	3.1
	115,578	88.5

Source: Coal Traffic Annual, 1979, p. III-4

Trucks

Although the trucking industry is a major transporter for the coal industry, trucks are used mainly for initial or final shipment over relatively short distances and usually are not involved in the long-haul market. However, their flexibility and low initial investment make them indispensable at small mines, where terrain is rugged, or where other modes are not available or feasible. For these reasons, trucks became the major mode of short-haul coal transportation during the last two decades.

Truck costs decline with increasing haul distance, but trucking remains the most costly mode of coal transport. Most coal trucks using public highways weigh 20 to 30 tons, but some of the off-road vehicles are as large as 170 tons. Because of the size of coal storage piles and the nature of the transfer operation, trucks have not played a significant role at the terminal end of the export coal trade. Small amounts of coal originating on the spot market have been trucked from Appalachian mines to ship terminals on the Great Lakes but the tonnages have been relatively insignificant.

Pneumatic Conveyor Systems

The transfer and handling of solids by the use of gases as a transport medium have been extensively used by various process industries for many years. Chemical manufacturing, metal and ore processing, the food industry and pharmaceutical manufacturing use gas-solid handling techniques (pneumatic conveying) in association with various unit operations and processes, such as size reduction, classification, drying, mixing, and blending in the production of many of their respective outputs. The transport distances are relatively short however, and further advances in the technology must occur before pneumatic transport can be used for long distances. This section will discuss in general the types of pneumatic conveyor systems, their advantages and disadvantages, and the application of such systems to coal transportation and transfer operations.

There are three general types of pneumatic conveying systems: (1) negative-pressure conveyors (vacuum systems), (2) positive-pressure conveyors, and (3) gravity movement of gas-buoyed particles. Additionally, there are combination systems which have both positive- and negative-pressure systems to give increased flexibility and ease of operation for special handling situations. The gravity movement of gas-buoyed particles is restricted to short distances and small changes in elevation: the fluidized beds often used in process industries are examples of this type of system. These are not suitable for the distance and elevation requirements of coal transport and transfer operations and will not be further discussed.

A negative-pressure system moves the solid particles by first suspending them in a gas, then moving them through a pipeline using the energy of gas expansion as the gas-solids mixture moves from the inlet, where pressure is greatest (the least vacuum) to the outlet part, where the pressure is least (the greatest vacuum). A canister-type vacuum cleaner is a more familiar example of a negative-pressure conveying system. The solids feeding mechanisms can be very simple in vacuum systems. An additional advantage for vacuum systems is the ability of this type of system to pick up materials at several inlet feed locations and transport to a single final outlet location.

Positive-pressure systems have higher operating pressures inside the system than the surrounding atmospheric pressures. Positive-pressure systems have been further classified into three subsets: "low-pressure" systems, operating at pressures up to 20 psig; "medium-pressure" systems, with air pressure from 15 psig to 45 psig; and "high-pressure" systems, with operating pressures of 45 psig to approximately 150 psig. The high-pressure systems would be most likely used for the transport of coal since the maximum transfer distances and elevations are attainable with these systems (Marchello and Gomezplata, 1976: 117). Positive pressure systems are the best choice where there is one solid feeding location to serve several outlet locations, such as in process industry plants.

The primary components of a pneumatic bulk material handling system are a gas mover (a blower or compressor), a solids feeding device and a solids collection system, including air pollution/dust containment equipment.

Pneumatic systems have been used for over 100 years for transporting and handling granular or powdered dry bulk materials. Their use for coal handling, however, has been limited almost exclusively to the movement of powdered coal into boiler and furnaces, primarily at electric utility steam generation plants. Table 3 lists properties and characteristics of materials which should be evaluated prior to the design of a pneumatic transport system. Table 4 gives a summary of various characteristics of coal and coal powder and the ability to use pneumatic systems for transport of these commodities.

Recent developments in employee health legislation and pollution control regulations emphasize the importance of controlling dust emissions. The control of coal dust during all phases of coal transportation and transfer operations is critical. This is the major cause of complaints regarding coal terminal activity. An effective dust control system will be critical in the satisfactory operation of a pneumatic system for coal loading or unloading. There are five basic methods of separating dust and particulates from air: (1) settling, (2) centrifugal action (cyclones), (3) wet scrubbing, (4) filtration (bag houses), and (5) electrostatic precipitation. There is extensive literature on these methods and particulate air pollution control in general. Whatever type of pneumatic conveying system (or any coal handling system) is used, suitable control technology will be required for the operation of the facility.

Given that the maximum transport distances for high pressure pneumatic systems are about 10,000 feet (the longest distance for any of the pneumatic systems), and that most coal is currently transported in lump sizes infeasible for use in pipeline, pneumatic systems probably will not receive widespread usage in the coal export industry without significant changes in the coal industry or transport technology. Such changes would have to include changes in the market demand (wanting smaller size granules or pulverized coal from suppliers) and the development of an intermediate transfer pressure boosting station for gas-solid pipelines, similar to natural gas pipelines booster stations. A breakthrough in developing an in-line, gas-solid pump/ compressor could permit solids to be air-transported over practically any distance.

TABLE 3

PROPERTIES AND CHARACTERISTICS OF SOLIDS TO BE EVALUATED IN THE DESIGN OF CONVEYING SYSTEMS

All Conveyor Systems:

Bulk density (capacity calculations)
Lump size greater than 3/4" lump (do not use screw conveyors)
Angle of slide (can material be conveyed on belt conveyor)
Flowability (ease of conveyance)
Floodability (difficulty of conveyance)
Toxicity or explosiveness of dusts (safety)
Shape, irregular or fibrous (difficulty of conveying)
Particle size
Corrosivity (materials of construction)
Material degradability (critical with some conveyors)
Contaminability

Important to Penumatic Conveyor System:

Packed bulk density (power and air requirements)
Aerated bulk density (feeder, hopper capacities)
Particle sizes (dust collector needs, feeder needs, type of seals, minimum conveying velocities)
Hardness (materials of construction, bearing needs, type of system)
Hygroscopicity (type of feeders, air drying needs)
pH and corrosiveness (air drying needs, materials of construction)
Cohesiveness (type of system, air drying requirements)
Floodability (type of system)
Angle of repose (hopper design, flow inducers in hoppers)
Toxicity (type of dust collector, venting systems in hoppers)

Source: Marchello and Gomezplata, 1976.

TABLE 4

CHARACTERISTICS OF COAL AND COAL POWDER TO BE CONSIDERED IN PNEUMATIC PIPELINE DESIGN

<u>Coal</u>

Bulk density:	50 $^{lb}/_{ft^3}$
Possible problems:	dust; abrasiveness
Cautions:	- can have or can form hard lumps - dust is harmful, may be an irritant - flamable; dust may be explosive if mixed with air - size reduction and classification difficult - fluidizing and solid-solid blending difficult - should not use screw conveyor systems

<u>Coal Powder</u>

Bulk density:	30 $^{lb}/_{ft^3}$
Possible problems:	dust; abrasiveness; flow
Cautions:	- dust is harmful, may be an irritant - flamable; dust may be explosive if mixed with air - mildly corrosive - may hang up, hygroscopicity affects flow - some difficulty with pneumatic conveyors reported

Source: Marchello and Gomezplata, 1976.

The most immediate application of pneumatic conveying systems appears to be in connection with existing rail and/or barge transit modes. The pneumatic system would function as a loader/unloader or as a gathering/ feeder system. It would perhaps compete with mechanical (belt) conveying systems or short haul truck transport (OTA, 1981:61).

Mechancial Conveyor Systems

Mechanical conveying and elevating equipment may be classified in the following catagories (Marchello and Gomezplata, 1976:8):

- Belt conveyors
- Screw conveyors
- Drag conveyors
- Pan conveyors
- Vibratory conveyors
- Bucket carriers
- Bucket elevators
- Screw elevators
- Skip elevators

Equipment manufacturers and suppliers have developed charts, nomographs and procedures to aid in the selection of the best equipment for a specific application. A trade organization, the Conveyor Equipment Manufacturers Association (CEMA), has defined about 80 types of conveyors and 10 types of elevators. CEMA has also developed extensive handbooks and references describing not only equipment but also material properties of many bulk solids often encountered in process industries (McNaughton, 1981:97-112).

Material properties and design constraints are the limiting factors in the use of mechanical conveying systems. Fine materials may produce dusts requiring enclosures, pollution controls, and explosion prevention techniques and equipment. Horizontal screw conveyors have an upper limit of approximately 200 feet due to torque and shear capacity limitations of equipment. Belt conveyors can be used for transports of several thousand feet, including substantial changes in elevation. The belt conveyor is the most feasible of the mechanical conveying systems and will be emphasized in this section.

Coal has been moved by belt conveyors over long and short distances for several decades. Conveyor usage has included hauls from surface mines to storage silos for loading unit trains, from mines to barge-loading facilities along rivers, and from mines directly to electric generating stations. The high cost of transportation relative to the value of the coal and the trend towards larger mines, and thus increased coal production from one region, are likely to expand the use of belt conveyors for coal hauling in the future.

The technology for long-distance overland conveyors appears to differ little from the technology existing for short-distance movements. "Belt conveyors are an old established method for the movement of bulk materials. They can handle large tonnages in difficult terrain. Where the competitive option is truck or rail transport, their high initial cost can sometimes be overcome simply because the route need not be as circuitous." (Campbell, 1979:38).

Several problems confront the use of long-distance belt conveyor systems for coal transportation. Legal matters, including the right of eminent domain for the developing company, and the status of the conveyor as a common carrier are as critical for belt conveyors as for coal-slurry pipelines. Environmental problems to be dealt with for conveyor systems include noise, dust, spillage, and aesthetic impacts on surrounding lands. Once in place, conveyor systems are not very flexible with respect to location or alignment changes. Like pipeline operations, failure at any point can jeopardize the entire system. However, control technology exists today to minimize the noise, dust, and spillage problems. Careful design and alternative route location analysis can minimize the visual and aesthetic impacts of such a system.

Conveyor systems, like pneumatic systems and slurry pipelines, are capital-intensive with little additional labor required as distances increase. The unit cost of transportation decreases as both throughput and haul distance increase. However, previous studies indicate that optimum economics are achieved when operating at steady-state conditions (OTA, 1981:61).

Belt conveyors will most likely be used, as will pneumatic systems, as an adjunct to existing rail or barge transport systems in the near future. As the legal difficulties previously mentioned are resolved, it is expected that belt conveyors will be more frequently used for the long distance transport of coal.

Slurry Pipelines

The movement of solid bulk materials as slurries through a pipeline is not a new concept. Commodities being commercially transported by this technology include iron ore, copper ore, copper concentrates, limestone, phosphate rock, sand, gravel, and coal. The first U.S. coal slurry patent was granted in 1891 to W. C. Andrews, who exhibited a working model of a slurry pipeline in 1890 at the Columbia World's Fair in Chicago. This section discusses slurry transport technology; some of the various legal, environmental, and political problems which have been encountered, and the applications of slurry transport to coal exports for either long or short distance movements or transfer operations.

Two coal slurry pipelines have been constructed and operated in the U.S. The Ohio Coal Pipeline, a 108 mile long, 10-inch diameter pipeline had an annual capacity of 1.3 million tons during its operation from 1957 to 1963. Built by the Consolidation Coal Company, it moved coal from a mine near Cadiz on the Ohio River to an electric power generation plant on Lake Erie, east of Cleveland. The pipeline was closed after the introduction of unit trains and a subsequent decrease in rates for coal movement by this new form of rail service. The second U.S. coal slurry pipeline is the Black Mesa pipeline (see Figure 1) which carries coal from the Black Mesa mine near Kayenta, Arizona to the 1500 megawatt Mohave power plant in Nevada, operated by Southern California Edison. The pipeline, 273 miles long and 18 inches in diameter, has an annual capacity of 4.8 million tons. Since 1970, the line has been in service with a reliability of about 99%, moving coal for about .15 cents per ton-mile (OTA, 1978:9; STA, 1981:5).

A schematic diagram of a coal slurry pipeline system is shown in Figure 2. A slurry pipeline involves the pumping of finely crushed coal suspended in a liquid transport fluid (usually water) through a pipe over fairly long distances. At the end of the pipeline, the coal and fluid are separated

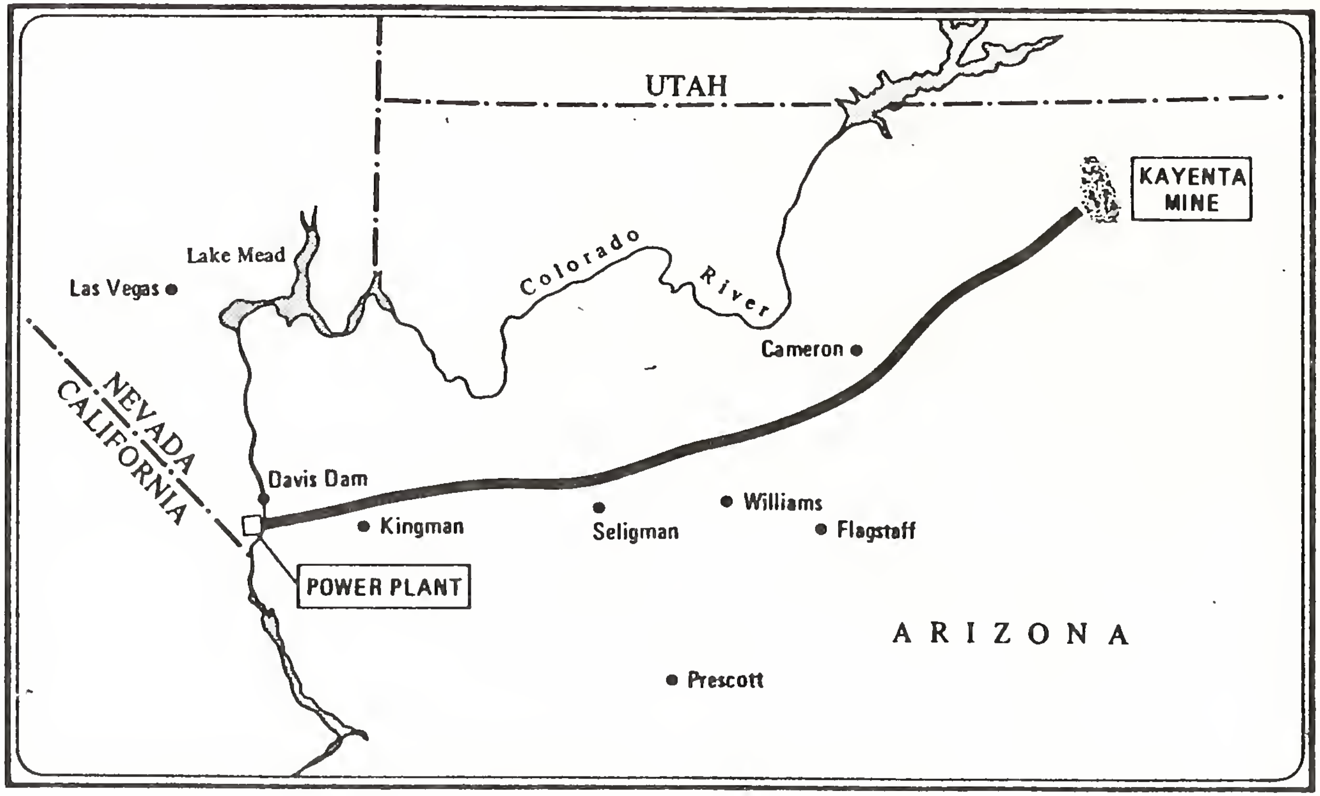

FIGURE 1

BLACK MESA COAL SLURRY PIPELINE

Source: Wasp, 1977:11.

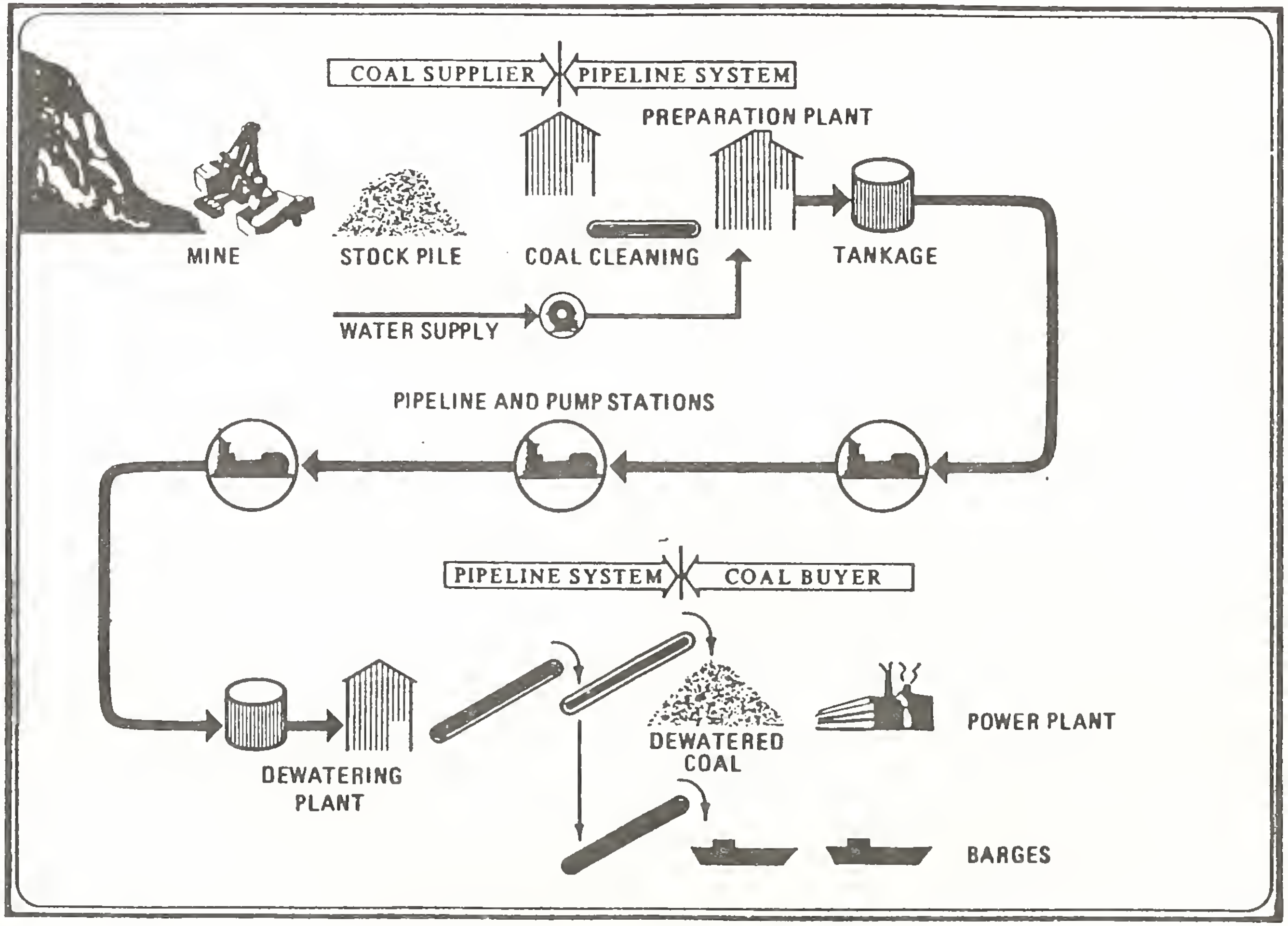

FIGURE 2

SCHEMATIC DIAGRAM OF A COAL SLURRY TRANSPORTATION SYSTEM

Source: Wasp, 1977:15.

using any of several different technologies (most often centrifugation; see Table 5), and the coal is prepared for combustion in boilers or furnaces or for some other use. The coal is usually cleaned prior to the grinding process to remove some of the sulfur content. The crushed coal is mixed with water to form a slurry approximately 50% (by weight) coal. The slurry travels along the pipeline at average velocities of 5 to 7 feet per second. Intermediate pumping stations are placed as required to overcome head loss due to friction and changes in elevation along the pipeline route. The discharge pressure at each pump station is about 900 pounds per square inch (psi); the pumps are usually of the reciprocating positive-displacement type. Table 6 is a summary of slurry pipeline design considerations.

At the receiving end of the pipeline, the slurry usually goes into agitated tank storage until needed. The coal is then dewatered and used as combustion fuel as mentioned above, or it can be loaded onto barges or colliers for further transit, either coastwise or to foreign coal markets. The pulverized coal is also in an acceptable form to feed coal gasification or synthetic fuel production operations.

Coal slurry pipeline systems can substantially help mitigate the large capital and operating costs which must be incurred in the development of expanded coal exports from the U.S. Ships equipped for slurry handling require only a pipeline connection to a simple mooring facility for loading/unloading. Docks, cranes, loaders/unloaders, conveyors, and other handling equipment are eliminated.

Using the technology developed for the oil industry, it is possible to transfer a commodity in slurry form from pipeline to ship to pipeline, at almost any coast with minimal environmental harm. A slurry terminal would have a shore-based storage area with two parallel pipelines running out to a single point mooring (SPM) buoy in deep water off the coast. One line would handle the slurry while the other would be used to recycle the conveying fluid. The SPM buoys can be relocated if economic conditions warrant such action at later times, an attraction not available to fixed-berth coal terminals. These SPM terminals eliminate expensive wharf facilities and the need for costly dredging of channels and harbors where draft limitations hinder the use of the "super-colliers." A closed loop discharge system

TABLE 5

COAL SLURRY DEWATERING TECHNOLOGY

Continuous	
Solid-bowl centrifuge:	Cylinder control bowl (vertical, horizontal): Solid screen bowl combinations.
Centrifugal filter:	Conical screen (helix, conveyor, oscillator); cylinder screen (pusher, conveyor).
Vacuum filter:	Rotary belt/drum, horizontal belt, horizontal pan.
Other:	Wet screens, cyclones, settling tanks, special filters and centrifuges.
Batch Automatic	
Centrifugal filter:	Vertical perforated basket, constant speed; horizontal basket, variable speed.
Screen-basket centrifuge:	Vertical basket, constant speed; horizontal basket, variable speed.
Batch	
Pressure leaf-filter:	Plate and frame; pressure leaf; vertical/horizontal leaf.
Settling tank	

Source: Wasp, 1977:136.

TABLE 6

OUTLINE OF SLURRY PIPELINE DESIGN REQUIREMENTS

I. Process Considerations
   A. Hydraulics
      1. Selection of a carrier fluid
      2. Selection of optimum particle size consist and solids concentration
      3. Determination of minimum operating velocity as a function of diameter
      4. Determination of friction losses as a function of diameter and velocity
   B. Corrosion-Erosion Rates
      1. Establish pipeline life (usually 20 to 50 years)
      2. Select corrosion inhibitor and/or oxygen and pH control
      3. Select metal allowance
         a. As a function of velocity
         b. As a function of particle size
   C. Abrasion Tests for Pump Wear
   D. Operability -- Stability
      1. Establish shutdown and startup requirements and capabilities
      2. Select maximum allowable pipeline slope
   E. Particle Degradation
      1. Establish the effect of pumping on the particle size consist (usually negligible)

II. Mechanical Considerations
   A. Select Type of Pumps to be Used (i.e., centrifugal or positive-displacement)
   B. Select Number and Location of Pump Stations
   C. Select Type of Driver (electric, gas, diesel)
   D. Establish Pipeline Construction Mode (buried or above ground)
   E. Automation Control
      1. Degree of automation
      2. Pump station synchronization (with positive-displacement pumps)
   F. Control of Pulsation and Vibration (for positive-displacement pump station piping)

III. Economic Factors
   A. Investment
   B. Operating Costs
      1. Maintenance of Slurry Pumps
      2. Corrosion Inhibitor Cost
   C. Optimization of Pipe Diameter and Power Costs

IV. Operational Considerations
   A. Select Mode of Operation
   B. Develop Shutdown and Startup Techniques
   C. Select Emergency Procedures
   D. Staffing Requirements in Isolated Locations

Source: Wasp, 1977:

eliminates all air and water pollution problems and cargo waste (spillage) associated with conventional dry coal handling systems.

Environmentally, slurry transport of coal has some obvious advantages over surface transportation modes. Traffic is not blocked and train-train or train-automobile accidents are eliminated. The land above the buried pipelines can be restored to productive use following construction. They cause no impediment to wildlife migration, nor any disruption of vistas or visual impairment to the surrounding lands. Slurry pipelines can move large volumes of coal continuously, with little or no noise, dust, or chance of explosion -- coal/water slurries are nontoxic and nonflammable.

The use of large volumes of water for slurry transport is often cited as an unacceptable environmental consequence. At 50% concentrations of dry coal by weight, a slurry pipeline would require one ton of water for every ton of coal that is moved. However, coal conversion processes including liquefaction and/or gasification require two tons of water for every ton of coal consumed. Electric power generation requires approximately seven tons of water (primarily for cooling) per ton of coal burned at a conventional steam power plant. Thus a slurry pipeline would use less local water than would a mine-mouth power plant or coal conversion plant. The water supply dilemma, primarily raised in the western states with the discussion of slurry pipelines to transport up to 25 million metric tons per year to the mid-south and Gulf states areas, may not be quite the problem in the states east of the Mississippi River. There may be some legal questions arising from the interbasin transfer of such large quantities of water. Salt water is not feasible to use for slurry transport, since the coal would absorb much of the salts from the water, causing increased boiler corrosion problems when the coal is later burned.

An important item for consideration in the planning and construction of a long-distance coal slurry pipeline is obtaining the required rights-of-way. It is necessary to obtain permission or permits (easements) for crossing highways, railroads, rivers, streams, and private and public lands. Approvals to cross such public lands must be obtained from state and federal agencies. Most of these permits are routinely acquired and pose few problems to the construction of a pipeline.

The major obstacle in obtaining the required rights-of-way is the railroads, which have historically refused to grant crossing permits to competitors (Wasp, 1979:42). Granting rights-of-way for coal slurry pipelines to date has met with strong opposition from the railroads which are trying to protect their "monopoly" on coal transportation. The railroads have mounted a large, well-funded opposition and openly admit their desires to restrict competition. Without permission to cross the railroads, there are three alternative ways to obtain rights-of-way: federal eminent domain legislation, state eminent domain legislation, and private acquisition.

The issue of eminent domain continues to plague slurry pipeline proponents. Unless the right of eminent domain is granted to the pipeline developers, either through state or federal legislation, it is unlikely that any major interior pipelines will be constructed. Thus, most proposals for slurry exportation projects require either rail or barge (or both) for delivery of coal to the slurry preparation plant (OTA,1981:60). North Carolina is one of ten states to have legislation either specifically granting eminent domain rights to coal slurry pipelines or having general eminent domain laws broad enough to include slurry pipelines (Wasp, 1979:41)[2]. For a more detailed discussion on the problems facing slurry pipeline development with respect to eminent domain and rights-of-way, see (Campbell, 1978) and (Wasp, 1979).

Several alternatives to "traditional" coal/water slurries have been proposed. In one scheme powdered coal and coal-derived oil form a nonaqueous slurry for movement through the pipeline. The slurry moves at temperatures of between 300C and 400C, causing the solvation of some of the coal (increasing the liquid fraction and decreasing the quantity of solids). At the end of the line, the slurry is separated into liquid and solid components which are then burned in separate facilities (Mechanical Engineering, 1979:46). The use of other fluids as a slurry transport

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[2] The other states are: West Virginia, Ohio, Arkansas, Louisiana, Oklahoma, Texas, Utah, Wyoming, and North Dakota.

medium, including methanol and oil (both natural and coal-derived) have been investigated. Coal/oil slurry pipelines are an attractive economic, environmental, and technically feasible alternative, provided that natural oil is available in the region. Coal/oil (derived or synthetic oils) and coal/methanol slurry pipelines do not appear to have any economic or environmental advantages.

Coal transported as a slurry is in a form which allows for storage of the coal under water in either ponds or tanks. This storage of coal slurry in ponds eliminates the problems of dust associated with conventional dry storage stockpiles, spontaneous combustion and weathering. The use of pond storage and pumping allows for a very simple and economical method of handling and, when required, blending of coals.

Overland transportation of coal by slurry pipeline is the most direct route for the movement between terminals and is not as limited by terrain as railways and overland belt conveyors. A pipeline may prove to be the only economically feasible method of crossing some unfavorable terrains. When buried, as in most cases, the line would be unseen, silent, and not subjected to weather, brushfire, or sabotage.

The primary competition of slurry pipelines is the unit train, a complete train of dedicated cars operating on a regularly scheduled movement between a single origin and a single destination, exclusively carrying one commodity, such as coal. Under certain circumstances, slurry pipelines can transport coal more economically than unit trains. The following conditions tend to favor slurry pipelines on any particular route (OTA, 1978:15):

- High annual volumes of coal shipped.
- Long distances to be traversed.
- High anticipated rates of inflation.
- Low real interest rates.
- Large, closely spaced sources of coal (mines).
- A secure market of several large customers located in such a manner to permit them to receive coal from a single pipeline.
- Terrain conditions favorable to pipeline excavation and construction.

- Availability of a sufficient water supply at low cost.
- Low cost of electric power for pumping requirements relative to that of diesel fuel for railroad locomotives.
- Circuitous rail routes, poor track, or other conditions unfavorable to railroads.
- Inefficient rail operations, including slow or short trains.
- Absence of a parallel navigable waterway.

The choice of a pipeline over rail transportation represents, in part, a decision to incur capital costs, which can be amortized at a predictable rate, rather than operating costs, which are subject to inflation. This decision involves weighing the real rate of interest one must pay on invested capital against the uncertainty of the inflation component or future operating expenses.

It is difficult to compare the economics of one specific rail movement with one specific slurry pipeline. If you make this system large enough, pipelines will compete favorably with rail in any situation. Approximately 70 percent of the costs of a slurry pipeline are fixed, thus it is less sensitive to inflation. Seventy-five to eighty percent of the costs associated with rail transportation vary with inflation. Pipelines are still in the early stages of development; many improvements in slurry technology may be feasible, especially when tied to coal gasification, desulfurization and/or liquefaction processes to exploit any synergetic benefits. There is no possible synergy between coal processing and unit trains.

A pipeline has a very definite economy of scale factor, the throughput rate of the pipeline being correlated to pipeline diameter at constant velocities. There is practically no economy of scale for unit train operations. A train set of 100 cars carrying 100 tons each can move 10,000 tons of coal per trip. If a one way trip takes 5 days to travel 1000 miles, one train can move about 365,000 tons of coal annually. To increase this throughput would require additional investment in cars and locomotives, with the increase in problems associated with train movements (traffic delays, noise, coal dust etc.).

The specific uses of slurry systems for the transport of coal to the coastal zone, or the use of slurry technology for coal transfer operations (offshore deep water loading/unloading) will be discussed in later sections.

2.2 Ports and Terminals

Coal terminal developments on the U.S. east coast as of June 1981 were reviewed in the Phase II Report (Volume 1, Section 3.2.1). Expansion of existing terminals and construction of new terminals were discussed on an individual port basis prior to the development of coal export capacity scenarios for the deepwater ports in North Carolina. Subsequent sections of this chapter will explore the opportunities and limitations of deepwater ports as they relate to the location and construction of coal export terminals.

2.2.1 Expansion of Existing Ports

Traditionally, most U.S. coal exports have moved out of Atlantic and Gulf coast ports, with the port of Hampton Roads dominating the export market. As the world's largest coal exporting port, the Hampton Roads coal terminals at Norfolk and Newport News have handled about 75 percent of our exports (51 million tons in 1980). Other major coal ports are Baltimore, New Orleans, Mobile, and Philadelphia.

The previously discussed expansion of world demand for U.S. steam coal that is expected to take place by year 2000 has resulted in plans to construct new terminals in the traditional coal exporting ports and to develop new projects at ports which have not previously engaged in the coal business. Before undertaking an investigation of new terminal concepts, three existing terminals will be discussed. Each of the terminals listed below was selected to illustrate a unique design concept:

(1) N & W Lamberts Point (Norfolk) Coal Pier No. 6--world's largest coal export facility in Hampton Roads.

(2) International Marine Terminal--located 40 miles below New Orleans and designed to handle western coal arriving by rail and barge.

(3) McDuffie Terminal in Mobile--a relatively new terminal located on an island in Mobile Bay.

Each will be discussed in terms of its capability to transfer coal from one or more inland transportation modes to oceangoing bulk carriers.

N & W Lamberts Point (Norfolk) Coal Pier No. 6

Norfolk and Western (N & W) Railroad and the Chesapeake and Ohio (C & O) Railroad (a subsidiary of CSX Corporation) provide the long-established rail access to the Port of Hampton Roads from the Appalachian coal fields. C & O operates facilities at Piers 14 and 15 in Newport News while the N & W owns and operates Piers 5 and 6 in Norfolk. Pier 5 operations are limited by 35 foot depth alongside the pier, but Pier 6, which has 46.5 feet of water, is the world's largest and fastest coal export terminal. Built in 1962, this pier, which is shown in Figure 3, has two movable shiploaders capable of a combined standard loading rate of 16,000 tons per hour. Pier 6 is served by 60 miles of classification tracks and can accommodate two colliers of 100,000 deadweight tons (dwt.) each.

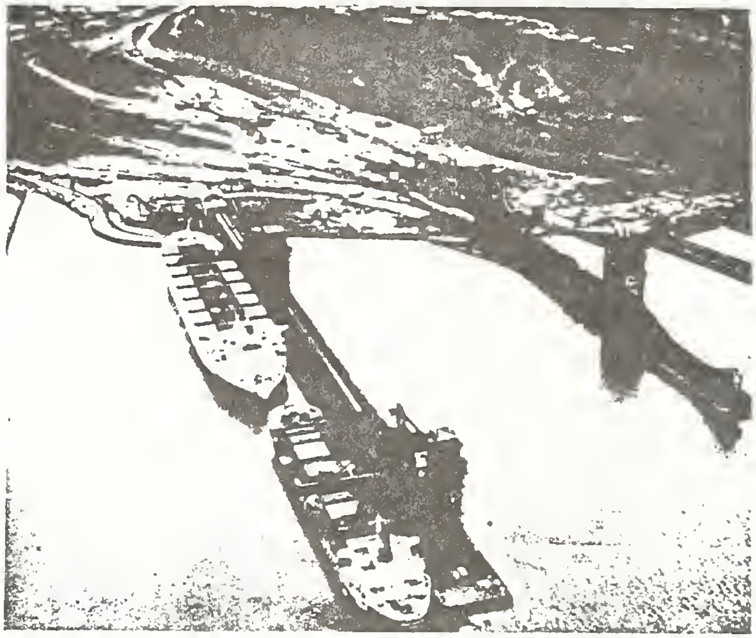
This facility includes four rotary dumpers which transfer coal from rail hopper cars to bins in a blending station from which it moves by 8-foot wide conveyor belts to the ship loading towers. These two towers can simultaneously load a single ship or operate independently.

International Marine Terminal

Located on the Mississippi River 40 miles below New Orleans, the International Marine Terminals (IMT) Plaquemines Parish Terminal (Figure 3) began handling coal exports in 1978. The facility was designed to accommodate western coal arriving by rail or barge, and midwest coal by barge alone. The IMT continuous barge unloader can transfer coal from barges to a 200,000-ton shore storage area at a rate of 1,500 tons per hour or directly from barge to ship at twice this rate.

McDuffie Terminal--Mobile, Alabama

The most recent major installation at the Alabama State Docks is the McDuffie Terminals bulk coal export terminal (Figure 4). It has operated at near capacity (5.2 million tons of throughput in 1980) since completion



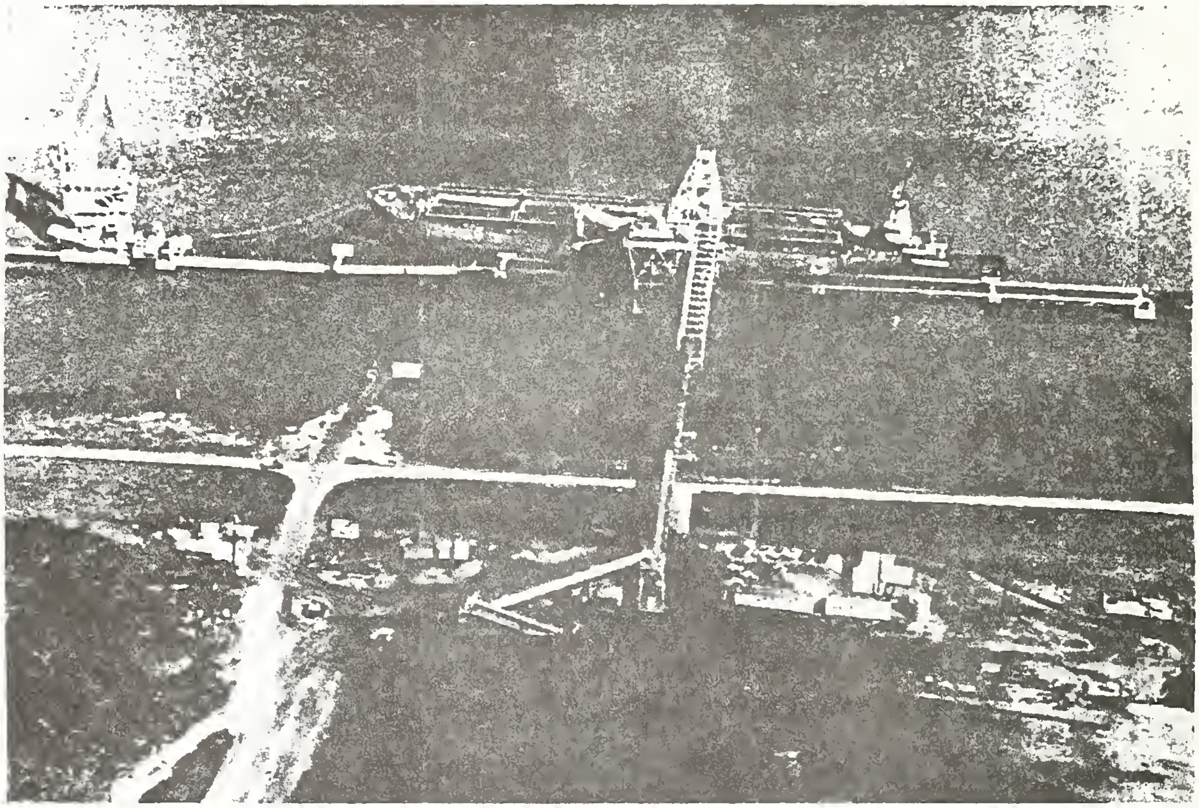


FIGURE 3

EXISTING COAL EXPORT TERMINALS
Top - N & W Lamberts Point (Norfolk) Pier No. 6
Bottom - IMT Terminal South of New Orleans

Source: Keystone,1980:212,221.

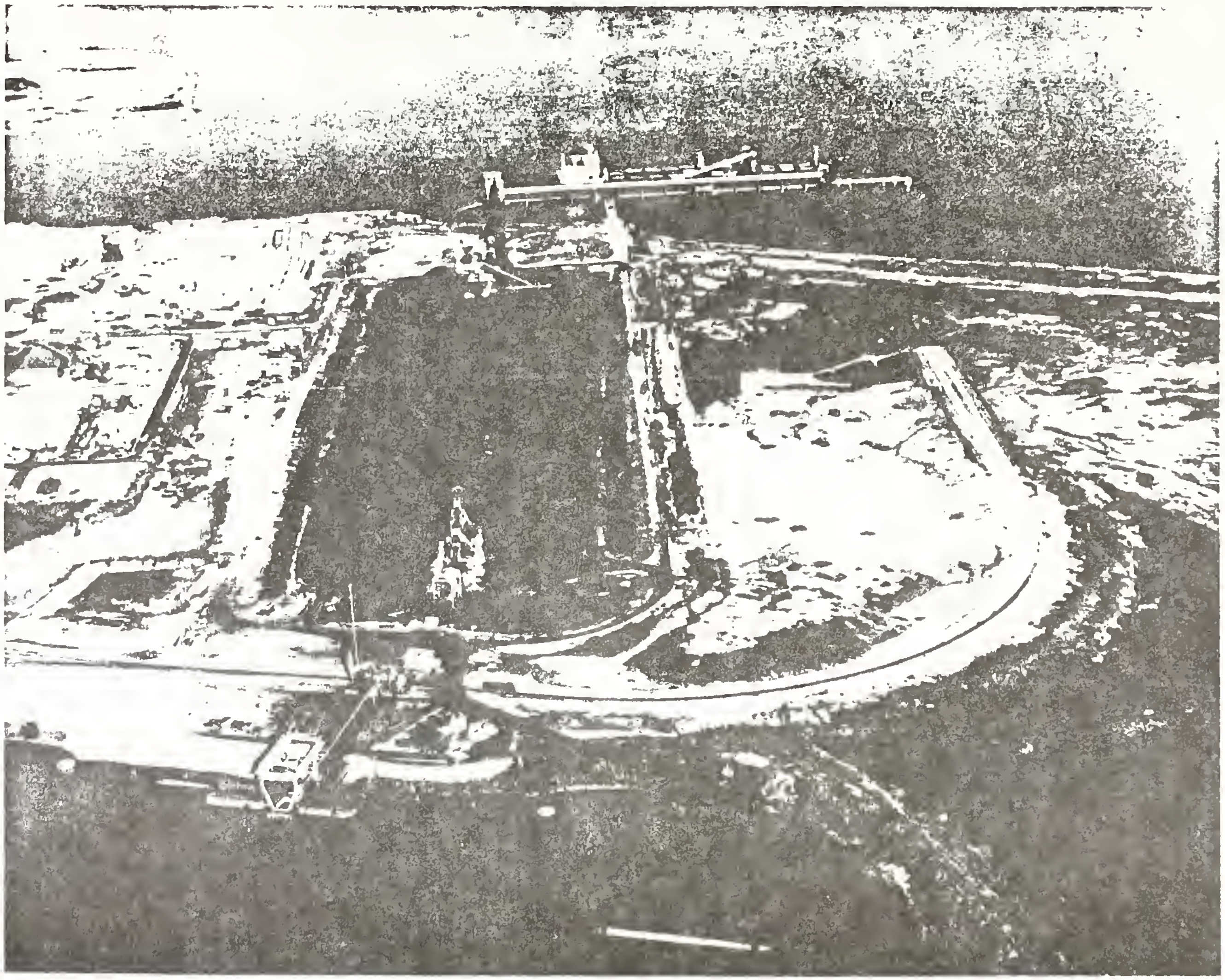


FIGURE 4
MCDUFFIE TERMINALS EXPORT COAL FACILITY - Mobile, Alabama

Source: <u>Keystone</u>, 1980:216

in 1975 and a current expansion program will more than double storage space and increase the throughput to about 7 million tons annually.

The coal terminal is strategically located near the mouth of the Mobile River with waterway linkage via the Warrior-Tombigbee Rivers to Alabama's coal fields. Additional tonnages of midwest coal are expected in the mid-1980's when the Tennessee-Tombigbee Waterway is scheduled for completion. Up to 32 barges can be accommodated in the staging area on the west side of the McDuffie Island where the barge unloader can handle up to 3000 tons per hour. After coal has been unloaded from barges or rail cars, it is moved along the conveyor that bisects the ground storage area. Coal can be transported directly to the shiploader or deposited in the storage area.

The Mobile River channel on the east side of the island is presently maintained at a depth of 40 feet so the loading pier can accommodate vessels up to about 60,000 dwt. Plans to deepen the channel to 55 feet would, if approved, permit super colliers to load at McDuffie Terminal.

2.2.2 New Terminal Facilities

The foregoing discussion of existing terminals implied that there is no single optimum design concept for export terminals. Each must satisfy the needs of the trade for the forseeable future while taking best advantage of its geographic and economic limitations. As a case in point, the older export terminals at Hampton Roads were designed primarily to accommodate the blending requirements for metallurgical coal. The resulting infrastructure, especially the rail storage yards and transfer equipment is expensive and not readily susceptible to expansion. So when a facility like the C & O terminal in Newport News or the N & W terminal in Norfolk reaches capacity, it may be difficult to expand. Such appears to be the case at the N & W Lamberts Point Pier 6 just described. The International Marine and McDuffie Terminals, however, were designed with future expansion in mind, and this could well be the trend for new terminals.

Intolerable ship delays, especially at Hampton Roads and Baltimore, have encouraged the expansion of existing terminals and the construction of new storage areas, piers, and handling equipment. The existence of a substantial rail infrastructure owned by the coal hauling railroads and the proximity of the Appalachian coal fields have supported the investment in new terminals on the Atlantic and Gulf coasts.

Proposals for numerous new facilities have been announced during the past year. It appears that every port on the Atlantic coast between New York and Jacksonville is initiating plans to enter the coal export business. Several new terminals are planned for the ports of Baltimore, Hampton Roads, Morehead City, and Wilmington while individual terminals are being considered in Port Reading, Camden, Philadelphia, Charleston, Savannah, and Brunswick.

As an example of current planning, the Port of Hampton Roads, the nation's largest coal-handling port, has expansion plans that could triple coal export capacity. The following projects, if implemented, would allow the port to handle 150 million tons per year, as compared with 50 million tons in 1980:

- The engineering consulting firm of Parsons, Brinkerhoff, Quade, and Douglas, Inc. plans to construct a 40-million ton terminal that will include a 4-million ton ground storage and blending facility.

- Most advanced of all development proposals in the area is the 60-acre A. T. Massey Coal Co. site adjacent to the Chessie pier at Newport News. It is expected to open in 1983 and offer 15 million tons of annual throughput capacity. Anticipating pier depths of 55 feet, the terminal has been designed to accommodate vessels up to 175,000 dwt.

- A state-owned facility with a throughput of 27 million tons per year is planned for 400 acres of land on Craney Island.

- Dominion Terminal Corporation has acquired 65 acres and plans a facility that will load 15 million tons of coal annually and serve vessels with a 55-foot draft.

- Higgerson-Buchanan, Inc. is building a 5-million ton terminal on 30 acres of land in Chesapeake, Virginia that is expected to open in 1982.

- Shawver Associates, Inc. plans another 5-million ton terminal on a 35-acre site in Portsmouth that is also expected to open in 1982.

2.2.3 Projections of Vessel Sizes

Most international coal shipments are transported by bulk carriers and combination vessels. Oceangoing bulk carriers are vessels specially designed for shipping a variety of dry bulk commodities such as iron ore, coal, grain, bauxite, or phosphate in large quantities. Combination, or OBO (ore-bulk-oil) carriers, vessels carry crude oil or refined petroleum products in liquid form or dry bulk commodities. At one time conventional cargo ships carried a substantial portion of world coal trade, but since the 1960's they have lost out to the economy-of-scale advantages enjoyed by the larger OBO's and bulk carriers.

The growing importance of larger vessels in the coal trade is illustrated in Table 7. A useful approximation between a bulk carrier's deadweight tonnage and its principal dimensions is provided in Figure 5. Since most major U.S. Atlantic coast harbors have channel depths in the 35- to 45-foot range, it is obvious that the drafts and resulting deadweight tonnages restrict the size of the vessels bound for the coal export terminals. Further comparisons of typical ship dimensions are provided in Table 8, where it can be seen that current shipments from U.S. coal terminals are limited to vessels less than 100,000 dwt.

Because unit costs of coal transportation increase with distance and decrease with ship size, the selection of ships tends to reflect a desire on the part of ship operators to use vessels as large as can be accommodated in the ports of concern. This has led to three general sizes of bulk carriers for coal: (1) 60,000 dwt. (Panamax size) which represents the median size for present coal shipments and is also the maximum size that can transit the Panama Canal (see Figure 6); (2) 100,000 dwt., which is presently the average size of the largest long-haul colliers; and (3) 150,000 dwt., which is estimated to be a common size for future bulk carriers (ICE, 1980:III-10,11).

Future size distributions of coal ships are expected to reflect the importance of economies of scale in long-distance shipments. Despite the fact that ship size limitations on the U.S. Atlantic coast are approximately

TABLE 7

NORTH AMERICAN COAL EXPORTS BY VESSEL SIZE, 1979

Vessel Size (dwt.)	Percentage
40,000	19
40,000 - 59,999	16
60,000 - 79,999	27
80,000 - 99,999	6
100,000 and over	32
	100

Source: OSG Bulk Ships Inc.; New York, February 1981

TABLE 8

SELECTED DIMENSIONS OF DRY BULK CARRIERS

Capacity (dwt.)	Overall length (ft.)	Beam (ft.)	Draft (ft.)
40,000	630	105	35
60,000	760	105	40
100,000	910	116	48
150,000	980	133	56
200,000	1,020	150	62
Limiting dimensions of Panama Canal	900	107	35.5

Source: OTA, April 1981:

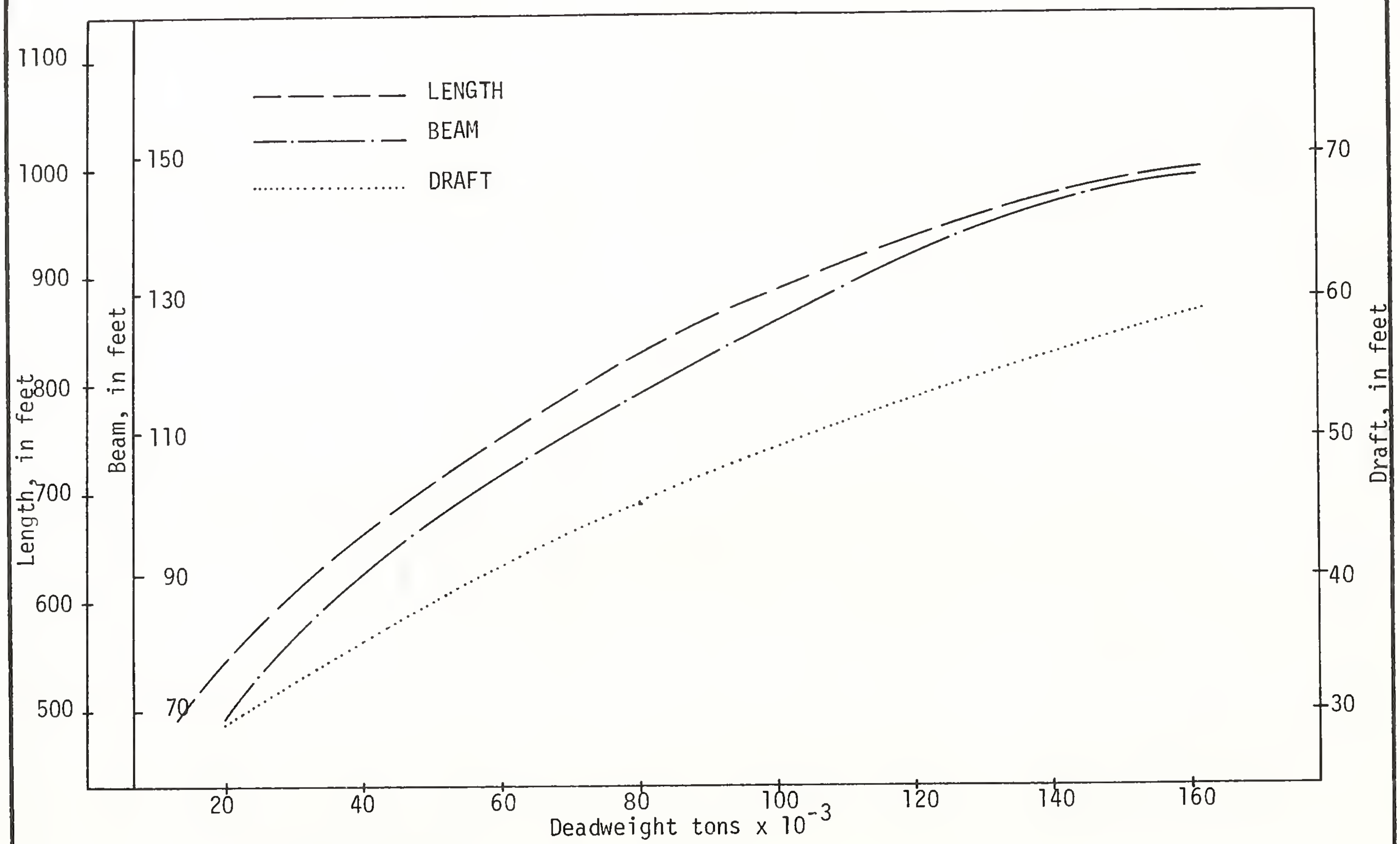


FIGURE 5

BULK AND ORE CARRIERS DIMENSIONS

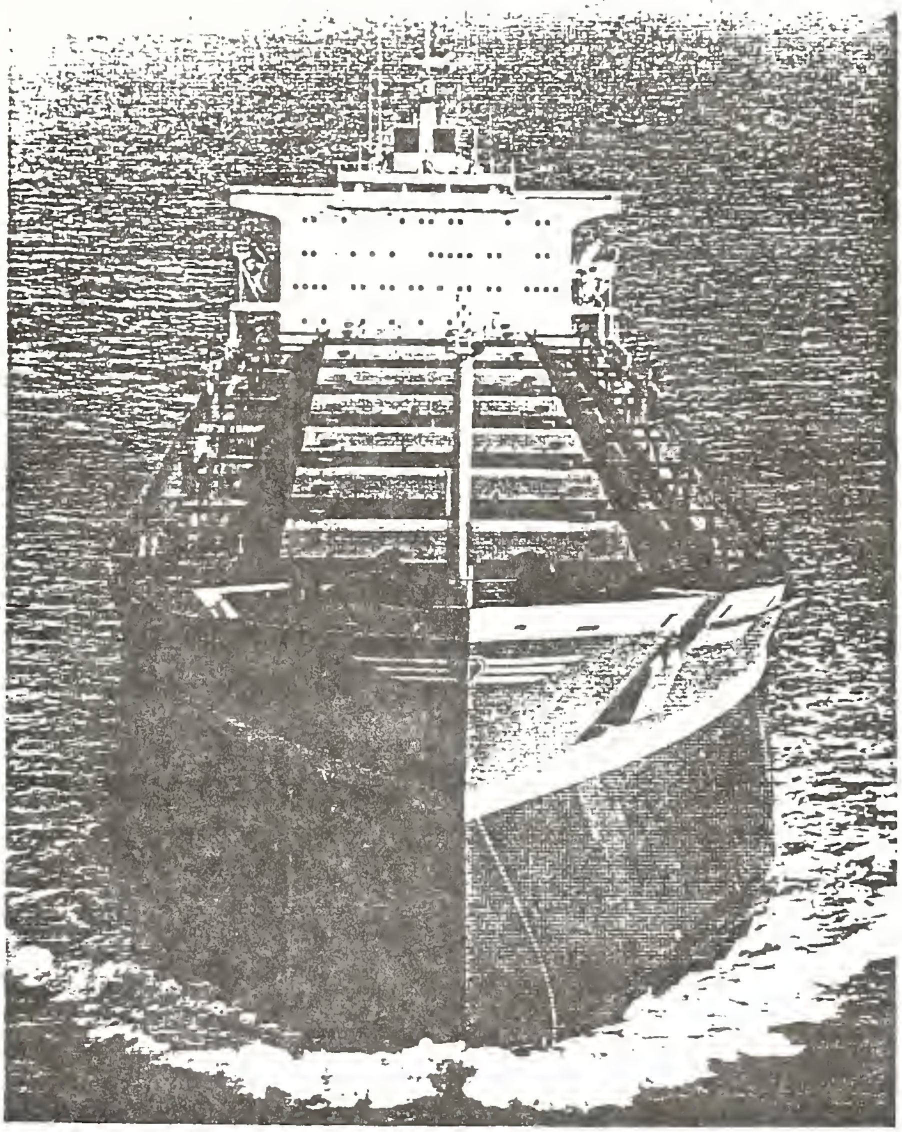


FIGURE 6
PANAMAX CLASS BULK CARRIER

Source: Marine Engineering/Log, June 15, 1981:77.

80,000 dwt. at Hampton Roads and 60,000 dwt. at shallower ports, about half of the world's coal fleet is 60,000 dwt. or larger. So it appears that increasing ship sizes, while not being accompanied by commensurate increases in port sizes in the United States, are being accommodated in other world ports. In fact, four export terminals and 14 receiving terminals are already in operation worldwide with facilities that can handle coal ships over 100,000 dwt. (Drewry, 1980). Deepwater export terminals at Richards Bay, South Africa; Roberts Bank, Canada; and Hays Point and Port Kembla, Australia are already providing strong competition for U.S. ports because of their ability to serve the larger carriers. Meanwhile, many receiving terminals in Western Europe and Japan have the capacity to handle coal carriers in the 120,000-160,000 dwt. range, and two ports in France are reported to be able to handle bulk carriers up to 650,000 dwt. (Lammert, 1981).

There is little reason to doubt that the anticipated growth in coal trade and potential economies of scale will make large bulk carriers more common. It has been estimated that within two decades, more than 50 percent of carriers capable of competing in the coal trades would exceed 100,000 dwt. and only 25 percent would be Panamax size and below (Lisnyk, 1981:52). Clearly, shipping capacity is not the critical factor in satisfying the anticipated growth in international coal trade. The critical question regarding American coal exports is whether or not U.S. ports can remain competitive with other world suppliers without deepening their channels or implementing offshore deepwater loading concepts.

2.2.4 Channel Dredging

If the United States is to maintain its leadership in the world coal market, many concerned individuals believe that several carefully selected harbors must be sufficiently deepened to accommodate super bulk carriers. As just discussed, the United States is the only major industrial power without deepwater port facilities for dry bulk commodities. Vessel draft restrictions are estimated to cost foreign coal buyers \$3 to \$4 more per ton in transportation costs than would be the case if adequate channels were available (ICE, 1980:7).

The most obvious solution to this problem is to consider dredging some of our harbors. To this end the U.S. Army Corps of Engineers has recently undertaken harbor and channel deepening studies at Hampton Roads, Mobile, and New Orleans. These studies respond to numerous Congressional resolutions which direct the Corps to determine the need for modifications at these locations. At Hampton Roads, the 1980 report recommends that the channels to the coal piers be deepened from 45 to 55 feet to accommodate vessels up to 120,000 dwt. Similar reports for Mobile (1980) and New Orleans (1981) also recommend increasing depths to 55 feet. Recommendations to deepen the 42-foot channels to Baltimore to 50 feet, which has been authorized since 1970, have been delayed due to a lack of dredged material disposal sites.

These studies led to hearings in July 1981 by the House Merchant and Fisheries Committee on two bills that would speed up channel dredging and split the cost between local ports and the federal government. Authored to aid ports in responding to the booming international coal market, the two proposals seek to reduce drastically the time it now takes the federal government to study, authorize, fund, and complete new projects. Each also calls for a nearly equal split of the cost of new dredging between the federal government and individual ports.

3.0 DEVELOPING TECHNOLOGIES

Conventional long- and short-distance systems for the inland movement of export coal from mine to port and coal movement and handling technologies in use at existing port terminals were discussed in Chapter 2. A number of new systems have been proposed for moving and handling coal. Most promising among these proposals are the following new concepts or modifications of existing technologies.

- Mine-to-Ship-Systems--Existing transportation systems may be replaced by new modes or bypassed by new routes that avoid present bottlenecks.

- Midstream Transfer--Transferring coal directly from barge to ship while anchored may avoid some of the prohibitive ship delays and demurrage charges.

- Barge-Carrying Vessels--Vessels similar to existing LASH or SEABEE ships may be able to load and discharge barges without actually handling their cargo.

- Shallow-Draft Vessels--Ships that can better adapt to shallow channel and harbor limitations by utilizing new length-beam-draft ratios may defer the need to dredge selected harbors.

- Offshore Deepwater Concepts--New coal export terminals with storage facilities ashore and single-point mooring devices located several miles offshore in deep water may obviate the necessity to construct new terminals in congested port areas.

3.1 Combination of Networks

Since World War II, production of U.S. coal has been relatively stable and the major eastern coal-haul railroads (CSX System, Norfolk and Western, Southern Railroad, and Conrail) have been able to satisfy most of the transportation needs for export coal. Almost without exception these railroads, along with several barge lines operating on the Mississippi and Warrior-Tombigbee River systems, have provided sufficient capacity to move Appalachian coal to export terminals on the Atlantic, Gulf, and Great Lakes coasts and there has been little need to consider alternative inland systems. However, conditions are rapidly changing and problems are beginning to surface at the export terminals and, in a few cases, along the inland routes serving these parts.

Particularly in North Carolina where coal export is a relatively new phenomenon, congestion, delays, and other potential impacts along the railroad moving coal to Morehead City are beginning to cause concern. As additional export terminals are constructed and the annual tonnage of export coal moving through the State's ports increases, the adequacy of the existing rail system may not be sufficient. Perceived rail impacts at New Bern and Morehead City have already necessitated the study of possible bypass facilities to ameliorate congestion in these urban areas.

While it is beyond the scope of this investigation to address specific rail problems in the Coastal Study Area, it might be productive to explore the possibility of replacing existing transportation systems with new systems or combinations of subsystems. These integrated networks might include one of the following combinations in North Carolina:

(1) Rail - barge combinations -- Coal would move by unit trains from Appalachian mines to barge transhipment terminals along the Pamlico or Neuse River where it would then move by water to the export terminals at Morehead City. Rail problems in New Bern and Morehead City would thus be bypassed.

(2) Rail - conveyor or rail - slurry pipeline combinations -- Export

coal would again be transported by unit train from Appalachia to a storage location on the landward side of Wilmington or Morehead City. From this stockpile it would move to one or more existing export terminals by means of a slurry pipeline or mechanical conveyor. Unit trains would not enter the port cities.

3.2 Midstream Transfer

At least four stevedoring firms in the Port of New Orleans are utilizing direct barge-to-ship loading, or "midstream transfer" of coal on the Mississippi River. The method employed is quite simple and is a common transfer technique in ports with limited berth availability. Coal laden barges are towed down the Mississippi and moored alongside bulk vessels at a general anchorage in the river. Several floating derricks equipped with grab buckets are used to transfer coal directly from the barge to the vessel (Figure 7), thus eliminating the need to wait for a berth at an existing coal terminal or perhaps, the need even to construct a new terminal.

Midstream transfer is obviously a very flexible loading technique since capacity can be rapidly expanded by adding cranes. Loading rates upwards of 30,000 tons per day using two cranes and two million tons per month using four cranes have been reported (Journal of Commerce, Feb. 17, 1981:22). The midstream system is not without its problems. In order to maximize efficiency, coal barges must enter the port area just as the oceangoing vessel arrives. Lengthy waits for either barges or vessels will increase the cost. As an example of the infrastructure required, one of the stevedoring companies, which has set up operations at miles 171, 172, and 180 on the Mississippi River, offers 10 floating cranes, towboats, and a fleeting area nearby with a capacity of more than 400 barges (Journal of Commerce, Feb. 17, 1981:10).

The New Orleans firms are currently receiving most of their coal from the Illinois Basin in southern Illinois, Kentucky, and Tennessee or from coal fields in Appalachia. Recently completed barge terminals along the upper Mississippi River also allow Western mines to ship coal eastward by unit train and then transfer it to barges for the trip to New Orleans.

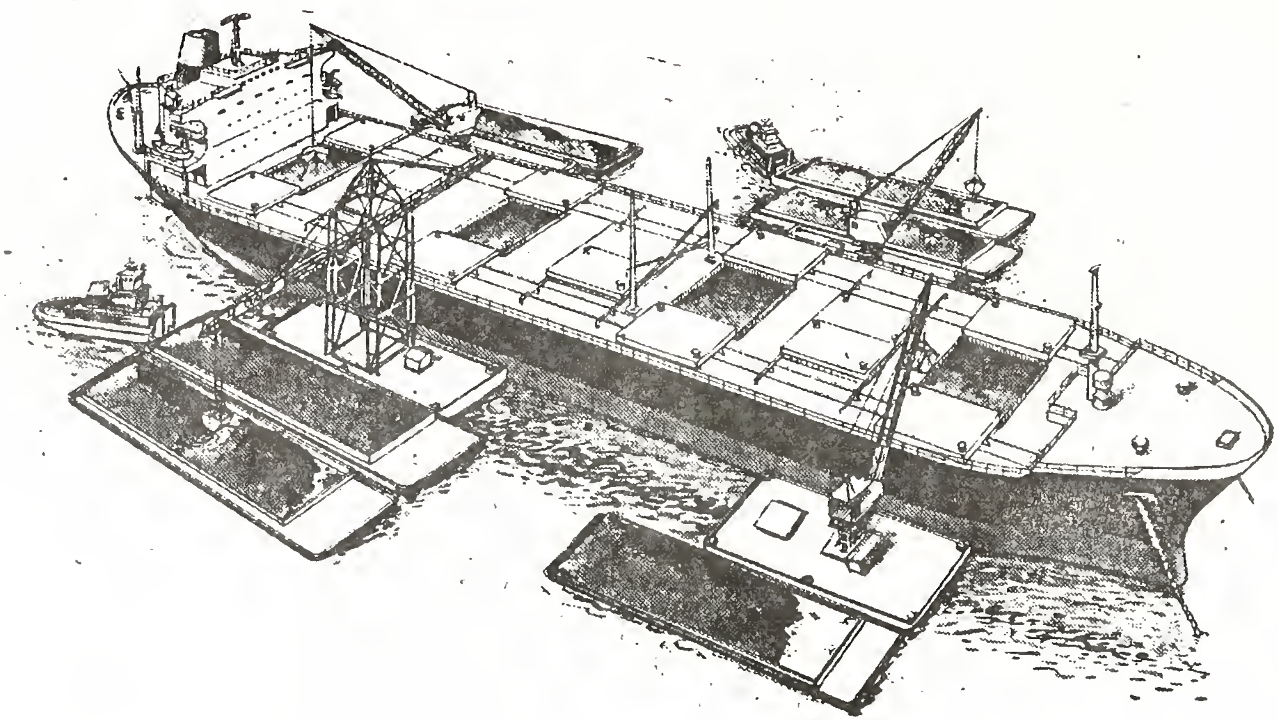


FIGURE 7

MIDSTREAM TRANSFERRING OPERATIONS

Source: <u>Bulk Systems International</u>, May 1981:28.

It is important to note that companies utilizing midstream transfer do not view their operations as just an interim solution to heavy congestion at east coast ports, nor do they feel they will be forced out of business when new coal terminals are constructed nearby. They reason that barge shipments of coal should always provide a cost-efficient alternative to rail movements to the east coast.

Two improved versions of this concept are being implemented or planned. Canadian steamship owners are initiating a system using self-unloading colliers to ship coal from the Great Lakes eastward through the St. Lawrence Seaway to Quebec City (OTA, 1981). At this deepwater port the self-unloaders will transfer coal directly to oceangoing vessels for the transatlantic voyage. Another proposal to barge coal eastward from the Great Lakes via a modernized Erie Canal envisages either midstream transfer to bulk carriers in New York harbor or transfer to an offshore industrial island complex to be constructed in the future (Marine Engineering/Log, August 1981).

3.3 Barge-Carrying Vessels

Barge-carrying ships, such as the LASH and SEABEE designs, have been used to transport general cargo for several years. A modification of this concept, where barges laden with coal would be loaded directly aboard ship, has been proposed as an alternative system for moving coal to Europe. By linking coal resources along the tributaries of the Mississippi River with industrial demand along selected European rivers, especially the Rhine River Valley, barge-carrying vessels could perform a special function.

A unique system of transporting existing river system barges (standard Mississippi barges measuring 195 x 35 x 12 feet with a 1,500-ton capacity) has been developed by Capricorn Corporation Ltd. (Lisnyk, 1981:49). A 110,000-ton capacity vessel can lift and transport 66 of these barges. Loading and discharging rates in the order of eight to ten barges per hour insure a rapid vessel turnaround without the need for shoreside cranes and transfer facilities.

Proponents of the Capricorn concept argue that it could eliminate the need for extensive port dredging projects and capital intensive coal export and import terminals. Nevertheless, inefficiencies in the form of empty back hauls could occur unless suitable return cargoes for the barges could be scheduled.

3.4 Shallow Draft Vessels

Another alternative for relieving coal port congestion without deepening the harbor and approach channels is to design and operate wide beam, shallow draft bulk carriers. For the typical 40-to 45-foot draft restriction encountered in most U.S. Atlantic coast ports, a 30 to 50 percent increase in deadweight tonnage can be obtained by accepting reasonable departures from "conventional" vessel proportions (OTA, 1981). The "conventional" design designation in this section refers to the proportional dimensions of ships which are currently in widespread use. Present dry bulk carriers are usually constructed to the following proportional dimensions:

$$\text{Length} = 7 \times \text{beam}$$
$$\text{Beam} = 1.8 \times \text{depth}$$

Traditionally, naval architects have designed a wide range of ship sizes in keeping with these basic length-to-beam and beam-to-depth ratios. As ship sizes increased, especially in the case of supertankers during the past two decades, their length, beam, and depth were increased in these conventional proportions.

Unfortunately, increases in vessel size have not been accompanied by commensurate increases in port channel depths in the United States. The development of shallow draft designs is an attempt to circumvent these channel limitations while taking advantage of the economies of scale available when using larger ships. A shallow draft design is achieved by making the vessel larger and wider without increasing the depth. The resulting dimensions alter the ships' relative proportions so the length is 5.5 times the beam and the beam is 2.3 times the depth. For a 40-foot draft such as is available in Morehead City, this increases maximum tonnage from approximately 60,000 dwt. for a conventional ship to about 90,000 dwt. for a shallow draft vessel. Comparisons of these designs are provided in the following table (Lisnyk, 1981:47):

Draft (ft.)	Max. dwt. Conventional Design	Max. dwt. Shallow Draft Design
35	40,000	60,000
40	60,000	90,000
45	85,000	125,000
50	110,000	170,000
55	150,000	225,000

It is important to note that several designs for this type of ship have already been prepared in the U.S. and a few shallow draft vessels for dry bulk applications have been built overseas. A technical assessment prepared for the U.S. Maritime Administration has revealed no major technological contraints to the construction of shallow draft ships.

3.5 Offshore Deepwater Concepts

A recent study of U.S. coal exports (I.C.E. Task Force, 1980) predicts that by 1985 as much as 25 percent of oceanborne coal will be carried in vessels larger than 100,000 dwt. that require a channel depth of 50 feet. By the year 2000 the study predicts that a common collier size will be about 150,000 dwt. and for such vessels a channel depth of at least 58 feet will be required. It has already been noted that major export terminals in Australia, South Africa, and Canada, as well as import terminals in Europe and Japan can already handle vessels of this size and, following planned expansion, will be able to accommodate ships up to 200,000 dwt.

Major U.S. coal ports on the Atlantic Coast -- Norfolk, Newport News, and Baltimore -- currently have maximum depths of 45 feet and future expansion is controlled by the 55-foot depth limitation imposed by the Chesapeake

Bay vehicular tunnel beneath the Thimble Shoals Channel. Other important coal ports on the Gulf -- New Orleans and Mobile -- lie on 40-foot channels which have maximum practical depths of 55 feet. North Carolina's two deep-water ports -- Wilmington and Morehead City -- have channel depths of 38 and 40 feet respectively. Until recently, the need for channels deeper than 45 feet was not critical because most of the U.S. coal exports consisted of metallurgical coal shipped from Hampton Roads via the Panama Canal (vessel draft limit = 40 feet) to the Japanese steel industry. As the demand for steam coal soared in 1980, the cost savings occasioned by the use of vessels larger than 100,000 dwt. took on added significance.

If channel limitations are critical to the future of U.S. steam coal exports and if the possibility for channel deepening is remote or environmentally unacceptable, it is reasonable to explore the feasibility of offshore deepwater loading facilities that could bypass the problems just cited. It appears that the technology for an offshore concept is presently available and that the most probable design alternatives would be either: (1) an offshore industrial island with a rail, pipeline, or conveyor connection to the mainland via a trestle, or (2) a single point mooring supporting a floating coal slurry hose which would connect to shoreside storage by means of a submarine pipeline. Adequate ground storage would be a prime requirement for either of these alternatives. Because of permitting requirements and the lengthy construction time required, the offshore island concept is considered to be the least viable option for North Carolina at the present time. For this reason, only the single point mooring concept will be discussed in detail.

Two specific solutions for transferring coal by submarine pipeline directly from rail cars or onshore storage to offshore loading sites have been proposed:

(1) <u>Hydraulic-transfer system (Boeing Company)</u>.
A cooperatively funded study (Boeing - Marad, 1979) sponsored by the Maritime Administration and the Boeing Company investigated the feasibility of exporting slurried Western steam coal to Far Eastern markets. It was undertaken in 1978-79 to study a trans-

portation system for moving 10 million tons of coal annually a distance of 650 miles via slurry pipeline to an export terminal in Southern California. There it would be stored in a slurry or semi-dry state until it could be recovered and loaded aboard large slurry/ore/coal/oil (SOCO) or dry bulk carriers for transport to the Far East. After unloading, the vessels would either return in ballast to the U.S. or proceed in ballast to Alaska where crude oil would be loaded for delivery in the United States.

(2) COSMOS System (Wheelabrator - Frye).

An innovative steam coal export system, Coal Slurry Marine Overseas System (COSMOS), has been proposed by Wheelabrator - Frye, Inc. COSMOS will employ conventional coal receiving and storage facilities that are located inland from the coast in combination with slurry loading and unloading and conventional unloading facilities. The company has indicated that it plans to construct, own, and operate this system in Mobile, Alabama and Morehead City and/or Wilmington, North Carolina (COSMOS, 1980). Each port would have an initial capacity of at least 5.5 million tons annually with expansion capability to 16 million tons.

The concept would utilize two basic configurations, each of which is intended to circumvent congestion at the export port:

- Slurry load/slurry unload
- Slurry load/dry unload

The first configuration essentially duplicates the international shipment of crude oil. Very large vessels (250,000 dwt. or greater) would load coarse coal slurry at a single-point mooring buoy located several miles offshore. A similar buoy installation would be required at the import port for liquid unloading.

The second configuration utilizes the largest ships currently in use in international coal trade (approximately 140,000 dwt.) and entails offshore loading in liquid mode and conventional unloading of dry coal at a foreign port.

Both the Boeing and Wheelabrator - Frye concepts are designed to bypass current problems related to inadequate rail facilities, congested export terminals, and shallow harbors.

4.0 DEVELOPMENT SCENARIOS FOR NORTH CAROLINA'S COASTAL STUDY AREA

Potential replacements for existing inland coal transportation systems were identified in the previous chapter. Obviously, some of them are not applicable to the unique needs of North Carolina. For example, midstream transfer of coal from barge fleets to deepwater vessels does not appear to be feasible because of the lack of navigable waterways from mines to State ports. Similarly, some of the existing inland transportation systems (e.g., mechanical conveyors, pneumatic pipelines, and trucks) must be eliminated as prospective long-distance alternatives on the basis of cost, technological difficulties, or negative impacts. They may be candidates, however, when used as short-distance links in a combination of systems. In the following sections, several transportation scenarios will be developed for each of North Carolina's major port regions and for a possible offshore terminal complex somewhere in Pender, Onslow, and/or Carteret County.

4.1 Morehead City Region

The Port of Morehead City offers a paradoxical mix of desirable features and unusual limitations when viewed as a possible location for coal export terminals. Its proximity to the open ocean, 40-foot channel and turning basin, year-round availability, and favorable labor situation are well known in the transportation industry. On the other hand, its limited landside transportation infrastructure, relative isolation from major market areas, and geographic limitations resulting from the location of the city and its port facilities on a peninsula have created unique problems for the Port.

Available land for industrial development in Morehead City is extremely limited and its utilization must be weighed against possible recreational use in a region that is already well established as a fishing, boating, and tourist area. Because Alla-Ohio Valley Coals, Inc. is already operating a coal export terminal at the existing Morehead Bulk Terminal and because this company, Gulf Interstate Corporation, and possibly other companies have proposed additional terminal facilities on Radio Island, significant concerns have been raised as to how the coal will reach the terminals without major disruptions to vehicular traffic and harmful environmental impacts.

Alternative coal transportation methods to Radio Island along selected corridors through or around the Morehead City area were extensively explored in a recent feasibility study (Soros Assoc., 1981), while alternative locations for the railroad that now bisects the city of New Bern were investigated in an earlier study (NCDOT, 1980). Additional investigations of local impacts in Morehead City, New Bern, and Wilmington and rail impacts in the Coastal Study Area are currently being conducted under a series of Coastal Energy Impact Program grants. This portion of the Phase III report will not duplicate these efforts but will seek to identify several possible combinations of alternative technologies for transporting and handling export coal in the Morehead City region.

Although they have not been subjected to any rigorous analysis of economic, social, or environmental feasibility, the following scenarios appear to merit further consideration for the region:

1. Rail - mechanical conveyor combination
2. Rail - slurry pipeline combination
3. Rail - barge combination
4. Offshore terminal
5. Rail bypass

Each of these five possibilities, along with the do-nothing alternative, have been compared in Table 9 on the basis of cost, technical feasibility, environmental impact, and social impact. The existing rail line through Morehead City would have no additional costs unless upgraded to handle increasing throughput, but the resulting environmental and social impacts would be intolerable.

The rail - mechanical conveyor combination envisions a new rail line to avoid the downtown area with an outlying stockpile and belt conveyor to the terminal. Conveyor technology is readily available but, depending on length and location, accompanying costs and environmental and social impacts may be relatively high.

Table 9

COMPARISON OF ALTERNATIVE TECHNOLOGIES FOR MOREHEAD CITY REGION

	Existing Rail	Rail-Conveyor	Rail-Slurry Pipeline	Rail-Barge	Offshore	Rail Bypass
Cost	1	2	2	1	3	3
Technical Feasibility	1	1	2	1	2	1
Environmental Impact	3	2	2	1	1	2
Social Impact	3	2	1	2	1	1

Legend: 1 - Good
2 - Fair
3 - Poor

Similar concerns exist for the rail - slurry pipeline scenario where social impacts will be less if the pipeline is buried. Slurry pipeline technology has had relatively limited utilization and problems concerning water supply may be prohibitive.

A rail - barge scenario offers a number of advantages, especially if rail problems in both Morehead City and New Bern can be bypassed. A barge loading terminal on the Pamlico River or on the north side of the Neuse River offers combined rail - barge service that could be quickly implemented at relatively low cost and could be easily expanded. Barge storage problems in the Morehead harbor, capacity problems in the Adams Creek Canal section of the Atlantic Intracoastal Waterway, or increases in rail freight rates could create difficulties for this combination.

An offshore terminal combining unit train delivery to a rural stockpile with a submarine slurry pipeline to a single point mooring would be extremely costly and require a long-range commitment of resources and contracts. However, it offers some major advantages that are not afforded by the other scenarios. Specifics of an offshore terminal will be discussed in a subsequent section.

A new rail line that would completely bypass Morehead City via Havelock, Core Creek, and Beaufort could provide Radio Island with direct rail service to a ground stockpile. Initial capital costs would be extremely high and environmental impacts could be extensive.

4.2 Cape Fear River Region

A review of the issues related to coal export in North Carolina (NCDNRCD, 1981: Table A.2) reveals that, during the past year, six companies have publicly expressed a desire to develop export facilities in the Wilmington area. These facilities include the following:

Company	Location	Effective Capacity (MTA)
American Coal	West bank Northeast Cape Fear R.	3 - 7
Cleancoal	Downtown Wilmington	3
Williams Terminals	Lower Cape Fear R. near Southport	10 - 20
Utah International	Lower Cape Fear R. near Campbell Is.	5 - 7
Wheelabrator-Frye, Inc.	Offshore Pender Co.	12 - 14
Carolina Coal	SPA Terminal	unavailable

Only two of these facilities, which are located on the east side of the Cape Fear River (Cleancoal and Carolina Coal), presumably would affect the transportation system for the City of Wilmington. The offshore site in Pender County will be separately treated in the next section. The three sites on the west side of the River -- American Coal, Utah International, and Williams Terminals -- will be served by existing rail facilities, and coal trains destined for these terminals would not enter the city (see locations on Figure 8). The American Coal facility north of the Hilton Railroad Bridge will be served by existing Seaboard Coastline Railroad tracks, while the Utah International and Williams Terminals facilities will be served by rail spurs from the existing U.S. government rail line to the Sunny Point Army Terminal.

At least in the early years of export terminal development, it does not appear that rail impacts, and consequently the need for alternative technologies, will be as great in this area as in the Morehead City region. Rail traffic at grade crossings serving the Carolina Coal site at the SPA terminal will increase, but the Cleancoal site apparently will not utilize any grade crossings. Certainly there will be additional impacts on the west side of the river, especially in the Boiling Springs Lake area, but because of the low population densities, they should be less severe. As a result, the need to replace or supplement present rail infrastructure with significant investments in new bulk conveyors, slurry pipelines, barge systems, or other transport systems does not seem to be especially critical at the present time. However, the need for short segments of new systems, e.g., conveyor belts to connect coal stockpiles with loading piers, should not be overlooked.

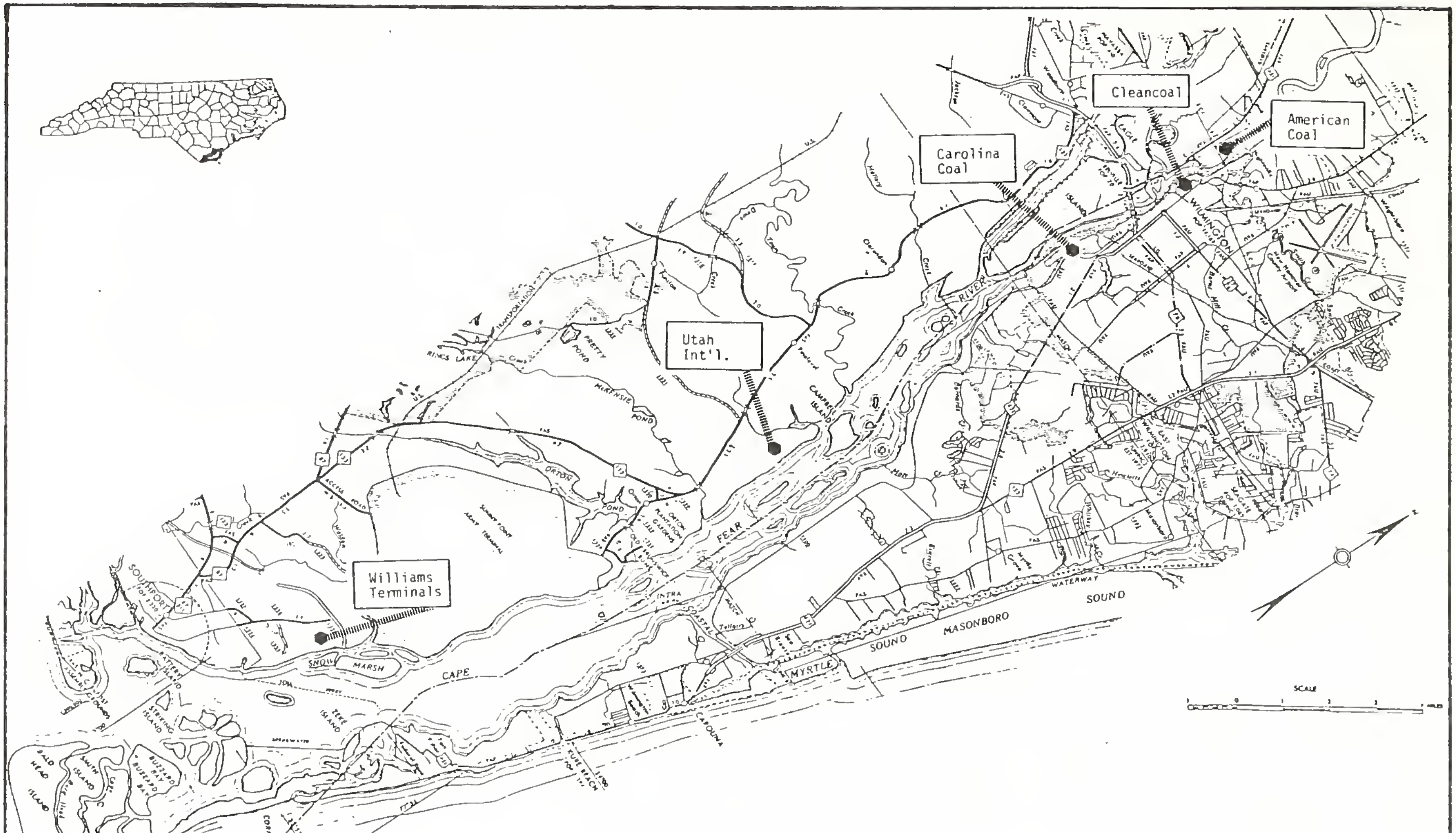


FIGURE 8
PROPOSED COAL EXPORT TERMINALS
CAPE FEAR RIVER

Perhaps of greater interest as a proposed technology for the Cape Fear coal facilities would be the possibility of employing shallow draft bulk carriers to export larger tonnages of coal without the need to deepen present ship channels. The concept of utilizing wide beam, shallow draft vessels was explored in Chapter 3 of this report. It is anticipated that the 38-foot channel limitation of the Cape Fear River will accommodate conventional vessels up to approximately 50,000 dwt. and could accommodate shallow draft vessels up to 80,000 dwt. If implemented, this concept could offer an extremely attractive alternative to costly and environmentally damaging channel dredging.

4.3 Offshore - Pender, Onslow, and/or Carteret County

In addition to the onshore terminal sites in the Morehead City and Cape Fear River regions, the possibility of one or more offshore sites between North Carolina's two deepwater port areas should be considered. The concept was discussed publicly at a National Coal Export Conference in Mobile in early 1981 and was also mentioned as a possibility for North Carolina in the COSMOS study (Wheelabrator-Frye, 1981: 2). As indicated in Figure 9, the four coastal counties -- New Hanover, Pender, Onslow, and Carteret -- between Wilmington and Morehead City quickly become the most logical candidate counties for an offshore terminal. Other coastal counties either lack the rail infrastructure needed to support a major terminal or are so environmentally sensitive that they should be excluded from further consideration.

The presence of Camp Lejeune Marine Base, the Croatan National Forest, and urban sprawl associated with the areas around Wilmington and Morehead City readily narrow the list of candidate counties. Only Pender County has significant amounts of undeveloped land that is served by existing rail lines. A coal terminal in this area would have access to the ocean without crossing barrier islands that have been developed for recreational purposes. Specifically, the area east of U.S. 17 between Scotts Hill and Hampstead (previously identified as Site C-18 in the CEIP Phase II Study) has access to Seaboard Coastline Rail facilities and also has easy access to offshore loading in relatively deep water. It is expected that the onshore unloading facilities for unit trains and stockpiles would be connected by submarine

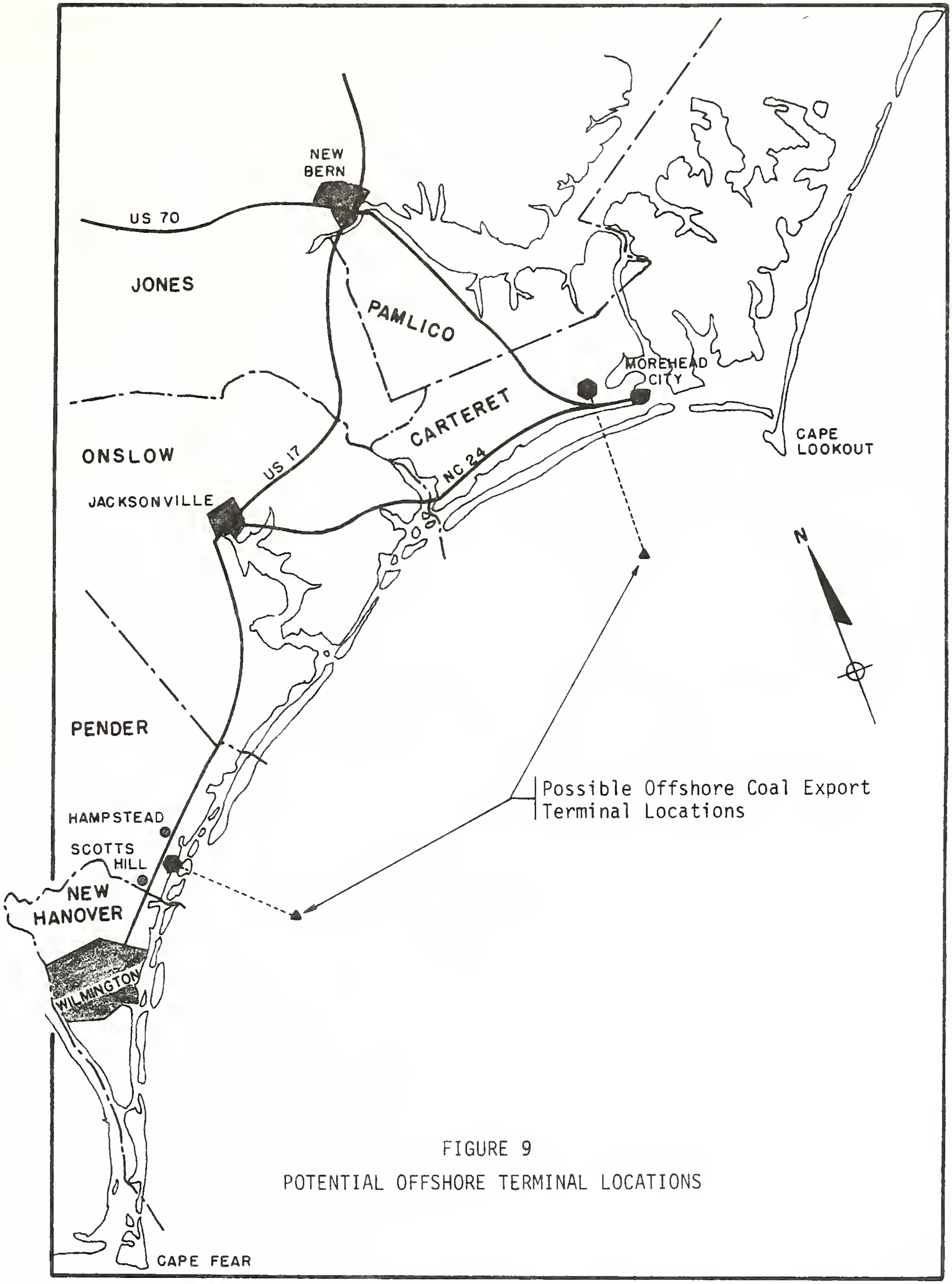


FIGURE 9

POTENTIAL OFFSHORE TERMINAL LOCATIONS

pipeline to deliver slurried coal to an offshore single point mooring device that could serve deep draft bulk carriers.

The possibility of a second offshore terminal site in Carteret County, just west of Morehead City, should also be explored. Suitable parcels of land for the onshore facilities can probably be found; but any sites in Carteret County must address the problems of unit train shipments through New Bern as well as the problem of constructing a pipeline through the highly developed recreational area of Emerald Isle - Atlantic Beach to reach an offshore loading site.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 Summary

Existing technologies for transporting and handling export coal were explored in Chapter 2. These included long- and short-distance conventional systems that are presently in operation and state-of-the-art facilities in existing ports. A review of channel dredging problems and vessel size projections led to a search for new technologies in Chapter 3. These included coal transporting and loading techniques that are currently being tested in other countries along with proposed concepts being utilized or investigated in the United States. The most promising of these alternative technologies were then explored in the context of three development scenarios for North Carolina's Coastal Study Area.

Morehead City Region

Because of the unique advantages and limitations of the Port of Morehead City, one scenario appears to be most promising:

- Rail - barge system to bypass New Bern and Morehead City

Cape Fear River Region

Coal terminal location along the Cape Fear River from Wilmington to Southport faces a different set of problems than those encountered in Morehead City. Because of its geography and well established rail infrastructure, new coal transport and loading technologies may not be needed in this region during the early years of development. The major problem could very well be lack of adequate ship channel depths to accommodate the larger, more efficient bulk vessels that are expected during the coming decade. Rather than dredge the 38-foot channel to a greater depth, the following scenario offers considerable promise:

- Employ wide-beam, shallow-draft vessels that could increase deadweight capacity up to 60 percent over conventional ships without any channel dredging

Offshore - Pender, Onslow, and/or Carteret County

The possibility of constructing an offshore coal export terminal complex in one of the two following locations offers a solution to many of the problems encountered by terminals in established port areas:

- Offshore coal terminal with onshore facilities in Pender County between Scotts Hill and Hampstead, N.C.
- Offshore coal terminal with onshore facilities west of Morehead City in Carteret County

5.2 Recommendations

It is recommended that two definitive studies be undertaken to explore the feasibility of the four scenarios listed above. A Landside Feasibility Study would investigate the rail - barge scenario for the Morehead City region and the wide-beam, shallow-draft vessel scenario for the Cape Fear region. The feasibility of the two offshore terminal locations would be investigated in the second study. A detailed analysis of costs, technical feasibility, and environmental and social costs of a reasonable set of alternatives under each of these scenarios would provide decisionmakers with additional input towards the solution of a most complex problem.

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GLOSSARY

Abbreviations (units)

psig - pounds per square inch gage

dwt - deadweight tons

Terms

OBO - Ore-Bulk-Oil carriers; cargo vessels capable of carrying a variety of liquid or dry bulk cargoes, as opposed to a tanker.

SPM - Single Point Mooring buoys

Collier - A dry bulk cargo vessel which transports coal.

CEIP Publications

1. Hauser, E. W., P. D. Cribbins, P. D. Tschetter, and R. D. Latta. Coastal Energy Transportation Needs to Support Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #1. September 1981. $10.

2. P. D. Cribbins. A Study of OCS Onshore Support Bases and Coal Export Terminals. CEIP Report #2. September 1981. $10.

3. Tschetter, P. D., M. Fisch, and R. D. Latta. An Assessment of Potential Impacts of Energy-Related Transportation Developments on North Carolina's Coastal Zone. CEIP Report #3. September 1981. $10. (Available spring 1982)

4. Cribbins, P. S. An Analysis of State and Federal Policies Affecting Major Energy Projects in North Carolina's Coastal Zone. CEIP Report #4. September 1981. $10.

5. Brower, David, W. D. McElyea, D. R. Godschalk, and N. D. Lofaro. Outer Continental Shelf Development and the North Carolina Coast: A Guide for Local Planners. CEIP Report #5. August 1981. $10.

6. Rogers, Golden and Halpern, Inc., and Engineers for Energy and the Environment, Inc. Mitigating the Impacts of Energy Facilities; A Local Air Quality Program for the Wilmington, N.C. Area. CEIP Report #6. September 1981. $10.

7. Richardson, C. J. (editor). Pocosin Wetlands: an Integrated Analysis of Coastal Plain Freshwater Bogs in North Carolina. Stroudsburg (Pa): Hutchinson Ross. 364 pp. $25. Available from School of Forestry, Duke University, Durham, N. C. 27709. (This proceedings volume is for a conference partially funded by N. C. CEIP. It replaces the N. C. Peat Sourcebook in this publication list.)

8. McDonald, C. B., and A. M. Ash. Natural Areas Inventory of Tyrrell County, N. C. CEIP Report #8. October 1981. $10 for all requests.

9. Fussell, J., and E. J. Wilson. Natural Areas Inventory of Carteret County, N. C. CEIP Report #9. October 1981. $10 for all requests.

10. Nyfong, T. D. Natural Areas Inventory of Brunswick County, N. C. CEIP Report #10. October 1981. $10 for all requests.

11. Leonard, S. W., and R. J. Davis. Natural Areas Inventory for Pender County, N. C. CEIP Report #11. October 1981. $10 for all requests.

12. Cribbins, Paul D., and Latta, R. Daniel. Coastal Energy Transportation Study: Alternative Technologies for Transporting and Handling Export Coal. CEIP Report #12. January 1982. $10 for all requests.

19. Pate, Preston P., and Jones, Robert. Effects of Upland Drainage on Estuarine Nursery Areas of Pamlico Sound, North Carolina, N. C. CEIP Report #19. December, 1981. $1.00.


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